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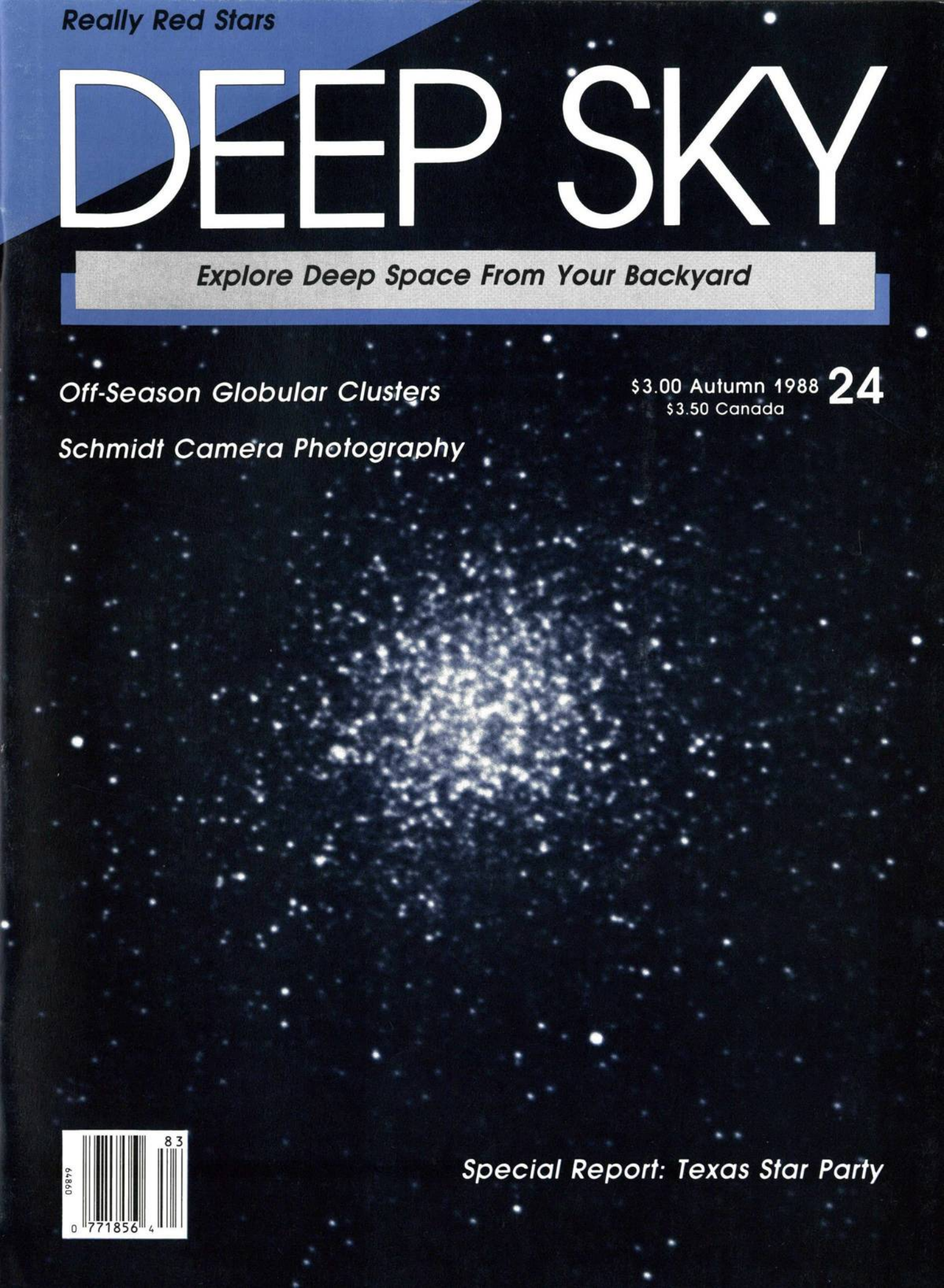

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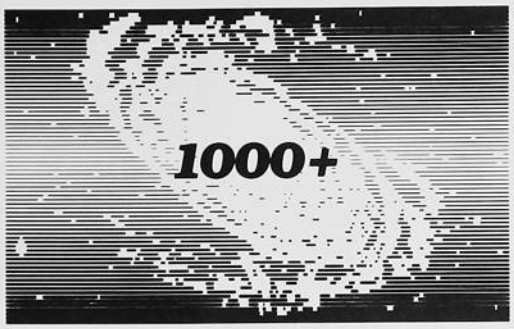

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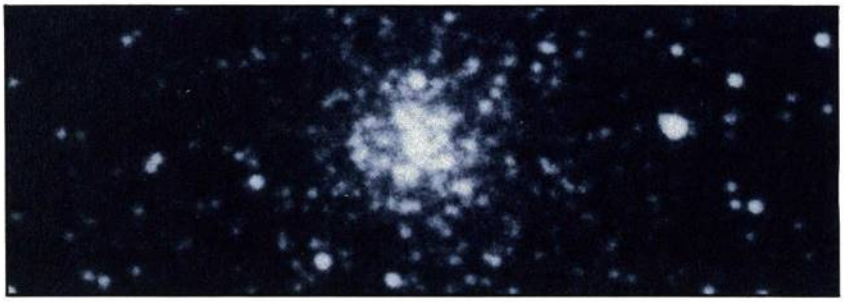

Off-Season Globular Clusters
by F. Michael Witkoski

10 *When you think of observing globular clusters, you probably imagine standing under the arcing glow of the Milky Way on a warm summer night. However, Mike Witkoski shows that impressive globulars are scattered in some pretty unlikely places.*

The Challenge of Schmidt Camera Photography
by Rick Dilsizian

18 *Schmidt camera photography is one of the trickiest methods of capturing deep-sky objects on film. But it allows unparalleled image sharpness and wide sky coverage.*

Profile of a Deep-Sky Sketcher
by Gregg D. Thompson

24 *Unfortunately, relatively few observers regularly make eyepiece drawings at the telescope. Gregg Thompson relates how he became involved with sketching and how it helps him search for supernovae.*

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DEEP SKY magazine (ISSN 0735-3073) is published quarterly by AstroMedia, a division of Kalmbach Publishing Co.,

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Second class postage paid at Milwaukee, WI. POSTMASTER: Send address changes to DEEP SKY, 1027 North 7th Street, Milwaukee, WI 53233. Direct all inquiries, editorial submissions, complaints, and other correspondence to the above address. Telephone (414) 272-2060. The opinions expressed in this magazine are not necessarily those of the publisher or editors. AstroMedia cannot be responsible for unsolicited materials. Names and addresses of authors may be printed unless specifically requested otherwise. Questions about subscriptions: (414) 272-2060, weekdays 8:30 a.m.-4:45 p.m. Subscription price (U.S.): 1 year $12, 2 years $21, single issue $3; (elsewhere): 1 year $14, 2 years $25, single issue $3.50. U.S.A. Newsstand Distribution by Eastern News Distributors, Inc., 250 West 155th Street, New York, NY 10019. Clubs and dealers: inquire about bulk rates.

THE MAGAZINE FOR
DEEP-SKY OBSERVERS
AND ASTROPHOTOGRAPHERS

Autumn 1988
Volume 6, Number 3

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ON THE COVER: Globular cluster Omega Centauri photographed by Tony Hallas and Daphne Mount with a 10-inch f/6 Newtonian from Mount Pinos, California.

Inside View

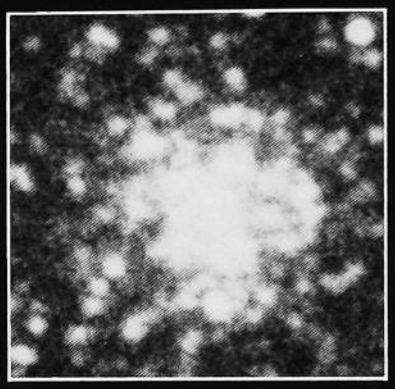
Heading into the Cold

When autumn begins, deep-sky observers often slump into a depression. (At least those of us in the Northern Hemisphere.) Temporarily gone are the warm nights when Sagittarius is in full view and the Cygnus Milky Way lies overhead. Instead we face the dull prospects of the "autumn void" and chillier evenings under the stars.

Despite fewer bright Milky Way showpieces, autumn stargazing can bring ample rewards for deep-sky observers. This issue's lead article describes a number of bright globular clusters that lie away from the plane of the Galaxy. Mike Witkoski's narrative will provide you with a great observing list for autumn and early winter.

Rick Dilsizian has something slightly more ambitious in mind. If you can stand to be out in the cold for long periods and you want to record autumn deep-sky objects, consider using a Schmidt camera. These specialized instruments not only offer short exposure times —many bright deep-sky objects can be recorded in two or three minutes — but also provide extremely wide fields of view. The trade-off for this perfect instrument for photographing large deep-sky objects is that the camera is somewhat difficult to use. Rick's description of Schmidt camera photography, beginning on page 18, runs alongside a selection of beautiful Schmidt shots.

Why does anyone become a deep-sky sketcher? That's the question posed (and answered) by Australia's Gregg Thompson in this issue's third feature article. Gregg's experience in making detailed sketches of deep-sky objects dates back to his desire to hunt for supernovae in galaxies, and it has kept him busily sketching ever since.



To round out this issue, we offer stories on the 1988 Texas Star Party, the elusive galaxy Maffei 1, autumn's galaxy groups, really red stars you can see with your telescope, and the visual challenge of the Crab Nebula.

I want to welcome Alister Ling and Gregg Thompson as contributing editors. Alister will be writing the "Small Scope Showcase" column beginning with the next issue, and Gregg will be writing on a variety of subjects. (This summer I got a phone call from David Levy saying "Help! I'm too busy to write two columns!" So we're lucky to recruit Alister to begin where David left off.) Also, fans of "Scanning the Literature" need not beware: it is missing from this issue only because of Brian Skiff's recent across-town move, and it will be back in the next issue. Until then, try not to let cold weather or autumn voids get you down — get out and observe!

Dave Eicher
Editor-in-Chief

Letters to DSM

Mystery Objects Unmasked!

Dear Mr. Eicher / In the summer 1988 issue Gregg Thompson offered more mystery objects for your readers to identify. I would like to offer the following identifications: the mystery nebulae are NGC 6726, NGC 6727, and NGC 6729 in Corona Australis. NGC 6726-7 surrounds the two brighter stars, and the 7th-magnitude southwestern star possesses a 13th-magnitude companion 4" away in p.a. 139°. The northeastern star is the erratic variable TY Coronae Australis. The smaller, comet-shaped nebula to the southeast is NGC 6729. This nebula is involved with the variable star R Coronae Australis.

Just across the border in Sagittarius lies the other mystery object, globular NGC 6723. This is a moderately loose cluster whose brightest stars glow at about 14th magnitude.

According to *Sky Catalogue 2000.0*, another nebulosity, IC 4812, lies about 3/4° southeast of NGC 6726-7 and is so plotted on *Sky Atlas 2000.0*. However, the original *Index Catalogue* position places IC 4812 one degree to the west on or near the double star mentioned by Thompson in his letter.

However, photos I have seen of the region show no nebulosity around this star. The original description of IC 4812, made from a photo, reads "a star of 7th magnitude in nebula." There is no 7th-magnitude star plotted on Tirion's atlas, and no other catalogue mentions nebulosity there. Is IC 4812 perhaps a photographic reobservation of NGC 6726-7, despite the 10' positional difference?

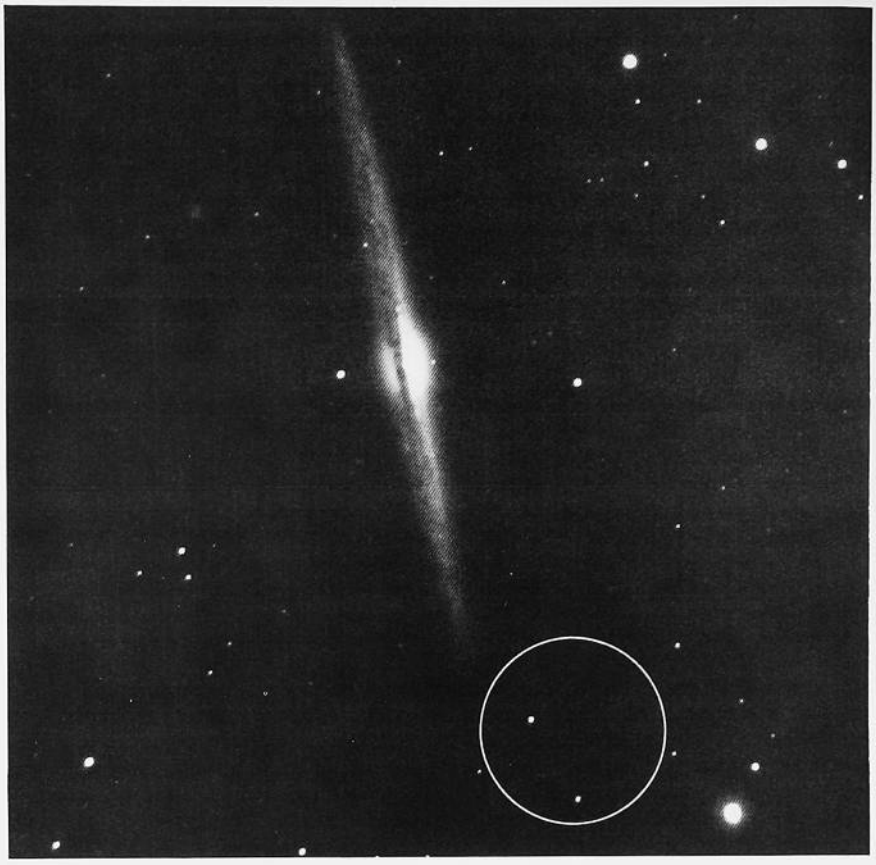
Eugene Brings
P.O. Box 582
Mendocino, CA 95460

Alfred Lilge 1925-1988

Dear Sir / Alfred Lilge, well-known amateur astrophotographer and frequent contributor to *Deep Sky*, passed away on June 10, 1988. An active member of the Orange County Astronomers, Al had an observatory on Palomar Mountain where for a time he worked as a night assistant. Before that Al worked for Boller and Chivens designing telescope drives and electrical systems. During his illness Al said he hoped his work "has led others to appreciate the beauty of the night sky."

John Sanford and Wayne Kaaz
2215 Martha Avenue
Orange, CA 92667

I had the opportunity to visit Al in his observatory for several nights in 1981. He was a warm, friendly person with a good sense of humor who will be greatly missed. — DJE



Barry J. Sobel

Bela Szentmartoni 1931-1988

Dear Sir / We let you know with broken heart that Mr. Bela Szentmartoni, the founder of the Albireo Amateur Astronomical Club, the editor of *Albireo* magazine for thirteen years, died unexpectedly on May 28, 1988, at the age of fifty-seven. Mr. Szentmartoni founded the Albireo club in 1971 and was a contributor to *Deep Sky* and the National Deep Sky Observers Society. In his last years he retired from the amateur community because of periodic illness. Of late he trustfully talked about his improving health. So he was carried away by death unexpectedly. We will greatly miss him for his magnificent but modest personality and happy nature.

Tibor Juhasz
Board of the AAAS
Zalaegerszeg
Munkasor u. 8.
H-8900 Hungary

Name That Galaxy Cluster

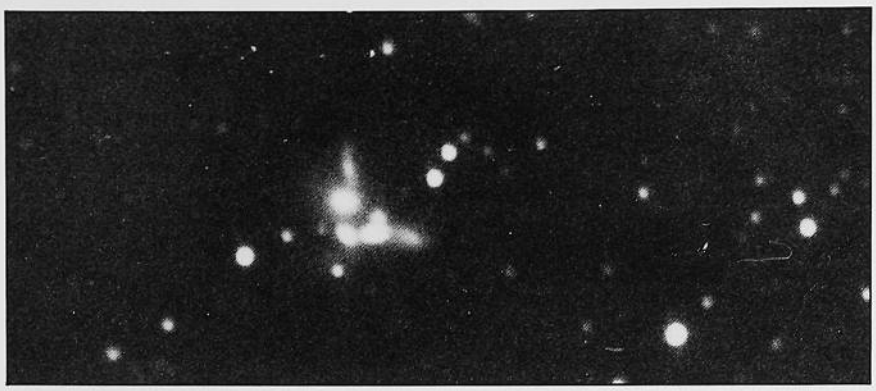
Dear Dave / I have enclosed a slide showing the beautiful edge-on spiral NGC 4565 in Coma Berenices. I made the photo with a 14-inch f/6 SCT, hypered Tech Pan, and a 70-minute exposure. Just off the southeastern end of the galaxy is a smattering of faint galaxies barely visible on the slide. Can anyone identify this galaxy cluster?

Dr. Barry J. Sobel
18370 Burbank Boulevard
Tarzana, CA 91356

Is Seyfert's Sextet Really Seyfert's Quartet?

Dear Dave / The article "Deep Sky Wonders in Ophiuchus, Serpens, and Scutum" in the summer issue contains a photo of NGC 6027, a galaxy group also known as Seyfert's Sextet. The group is discussed by Margaret Burbidge and W. L. W. Sargent in *Pontificae Academiae Scientiarum Scripta Varia* #35, 1971. They provide redshifts in the range of 4141 to 4581 km/s for galaxies a, b, and c, and a redshift of 19930 km/s for galaxy d.

Depending on your point of view, galaxy d is a member of the group with an "anomalous" redshift or a distant galaxy accidentally in the line of sight. The magnitudes range from 14.7 (NGC 6027 itself) to 16.0 for galaxy d. Object



The NGC 6027 galaxy group photographed by Alexander Brownlee with a 16-inch telescope. Should Seyfert's Sextet be demoted to Seyfert's Quartet?

e, with a magnitude of 16.5, is regarded as luminous matter tidally distorted from NGC 6027.

So perhaps Seyfert's Sextet is really a quartet. Apart from that, the group is interesting for its extreme compactness. Also, if galaxy d is at its redshift-indicated distance, then it is very much on the high end of the absolute magnitude range, although not outrageously so.

Alexander Brownlee
P.O. Box 127
Ouray, CO 81427

Sketch by Steve Lucas
13.1-inch f/4.5 telescope at 166x

Palomar 5 Sighting

Dear Dave / I enjoyed David Higgins' summer issue article on the Palomar globular clusters so much that I went out and tried to view one of the clusters. On June 17, 1988, Rich Marcisz and I used Rich's 16.4-inch f/4.8 reflector to track down Palomar 5 in Serpens. We brought along my blue-sensitive copy from the Palomar *Sky Survey* to aid in pinpointing the cluster's exact location. We knew it would be difficult, because Palomar 5 has an extremely low surface brightness. The cluster measures 6.9' across and glows at magnitude 11.8.

Using his finder scope, Rich spotted the square asterism of stars that harbors the cluster. We inserted a high magnification eyepiece, but that didn't show us anything. We then inserted a Nagler 13mm eyepiece and observed very faint specks of light, twinkling in and out with the seeing, at that location. We saw no definite shape, only four or five minute points of light clumped together.

I made a follow-up observation on June 17 using a 13.1-inch telescope at Lake Village, Indiana, and was only able to see one or two faint stars at that location.

Steve H. Lucas
14400 Kolin Avenue
Midlothian, IL 60445

Dear Dave / During the few years I have been observing deep-sky objects, I have grown to enjoy "filling up" my field of view with multiple objects lying in groups. Low-power fields containing M81 and M82 or M65 and M66 are examples. This is why I quickly recognized Gregg Thompson's "mystery objects" in the summer issue.

Flipping through some of my drawings, I found versions of all of the objects sketched together in a 70x (approximately 1°) field. The objects, globular NGC 6723 and reflection nebulae NGC 6726-7, lie at the Sagittarius-Corona Australis border. My notes from observing them read:

"Three NGC objects in the same field. The globular, NGC 6723, is easily resolvable and dominates the field. Two sets of doubles, one with nebulosity glowing faintly around its southernmost star, appear to the southeast of NGC 6723. Between the two doubles, slightly to the east, is a 12th-magnitude star with a wisp of nebulosity extending away from the globular. The nebulosity is fan-shaped, giving this object a comet-like appearance similar to Hubble's Variable in Monoceros.

"With direct vision the fan is small and rectangular, but with averted vision it grows to twice the length. With a little imagination, the 'comet' appears to be in orbit around the globular!"

Gregg's sketch is upside-down compared with mine. Our mates down under probably have the best view of this region as I suppose it rises directly overhead. In Arizona the group barely rises over the cactus tops! I believe this is a difficult group of objects from Milwaukee. Nonetheless, it is a great area that should be viewed by one and all.

Does anyone else have multiple-object fields they would like to share?

Bernie Sanden
4508 East Chambers
Phoenix, AZ 85040

NGC 6723 from Milwaukee? Forget it! My best views have come under the dark skies at the Texas Star Party. — DJE

Dear Dave / I was quite excited to open the spring 1988 issue and find David Higgins' article on the Palomar globular clusters. These heavily obscured or distant clusters represent unexplored territory for most amateur observers; in fact, both *Sky Catalogue 2000.0* and the Webb Society's *Deep Sky Observer's Handbook* warn that these objects are beyond the limits of visual observing!

Dana Patchick and I have been trading observations of the Palomar globulars for the past few years and can verify that at least seven of them are visible in 13.1-inch and 17.5-inch scopes. Palomar 6, 7, 8, 9, 11, 12, and 13 can all been seen visually. The following objects were not described in David's article.

Palomar 6 lies in southern Ophiuchus near the Sagittarius border. In my 17.5-inch scope, this cluster appears as a very faint, fairly large diffuse glow with six to eight faint stars superimposed including a colinear trio near the cluster's southern edge. This highly obscured cluster is barely visible on the blue *POSS* plate and quite prominent on the red plate.

Palomar 12 can be found 2.4° northeast of M30 in Capricornus. All I could detect with my 17.5-inch scope was an extremely faint, hazy region extended northwest-southeast and situated just northwest of a triple star. Two stars were superimposed on the cluster's background glow.

Nudge your scope 37' northeast of the beautiful barred spiral NGC 7479 in Pegasus and you may detect the dim glow of Palomar 13. With my 13.1-inch scope I detected an extremely faint, moderately large, round glow with no central condensation. A single star lies off the east side and three or four faint stars are involved in the cluster. I would be interested in hearing about other sightings of the remaining seven globulars.

Steve Gottlieb
1020 Ramona Avenue
Albany, CA 94706

Pro and Con on Messier Marathon

Dear Dave / In the summer 1988 issue a letter from T. C. Hoffelder explains the rationale for Messier Marathons. In the same issue David Levy refers to a "misguided" person originating the marathon. He is thankful that the competition has gone "out of fashion." The Messier Marathon is certainly not out of fashion at *this* end of the "lower 48," and I suspect that some West Coast observers enjoy the romp through the catalogue as well. The Northeast Region of the Astronomical League has sponsored such competitions, spurred on by Phil Harrington, a contributing editor to *Deep Sky*.

I'm a bit surprised at David Levy's statement, as I know his dedication and sincerity are considerable. His efforts to bring astronomy to kids (of all ages) are famous. At a conference of planetarium directors back in 1986 I had the distinct impression that David Levy would endorse *any* project that involved large numbers of enthusiastic observers. Can it be so bad, then, when dozens of telescope users in as many clubs "do" the Messier Marathon? I recall the time when all the seats in the school planetarium I work at were removed to allow a small group of amateurs to practice their search patterns before going out under the sky.

It's nice to enjoy the flowers one at a time, but a romp through the field can be just as exhilarating an experience. Come to think of it, my own subscription to *Deep Sky* was extended as an award for winning one of the marathons. Thanks, Phil. Dave Levy? Shame on you (with a smile, of course!).

Sam Storch
18 Hastings Drive
North Merrick, NY 11566

Dear Dave / This summer's *Deep Sky* held many attractions, as I have come to expect (Gee, I wish it arrived monthly!). I must add my two cents worth to David Levy and T. C. Hoffelder's comments on Messier Marathons. While M30 is one of the most difficult objects to spot, it is far from "impossible" as Hoffelder suggests. Messier Marathons may only be successfully concluded approximately every third year, when the New Moon coincides with the Sun's appearance at the vernal equinox. And even then the particular evening chosen during the few days of optimum observing make a great deal of difference.

I agree completely with Hoffelder's expression of the value of such an exercise, irrespective of the number of objects seen. And I agree in general with Mr. Levy's fine article on the value of Messier hunting to the observer in learning one's way around the night sky. However, I find his description of the originator of the marathon as "misguided" to be sadly deprecatory and somewhat short-sighted for as astute an observer as Levy has proven to be.

Mr. Hoffelder has defended well the excitement and sense of accomplishment that accompany a marathon. And Levy states as much when talking about the nonmarathon Messier hunt in general. However, I believe he is misinformed when he states that the Messier Marathon has gone out of fashion, however thankful he may be for its supposed demise. The Messier Marathon is alive and well and resides in the hearts of those who wish to exercise skills doing something just to say "I did it!" I urge Mr. Levy to keep an open mind to all of the activities that may ensue when the intelligence and instruments of amateurs are brought to bear on the cosmos, either collectively or individually.

Tom Lorenzin
P.O. Box 700-C
Davidson, NC 28036

I love Messier Marathons; in fact I did them twice in 1983, catching 109 Messiers, 33 NGCs, a few variables, and two episodes of Star Trek *all in the same night. I do endorse any project that gets large numbers of people away from the TV and closer to the eyepiece.*

However, the Messier Marathon loses some of its teaching value because the lesson is cramped into too short a time. And the quality *of individual observations suffers. The Messier Marathon is useful* only *if accompanied, as mine was, by careful note taking. Don't just add up numbers. — David H. Levy*

Mixed Planetaries

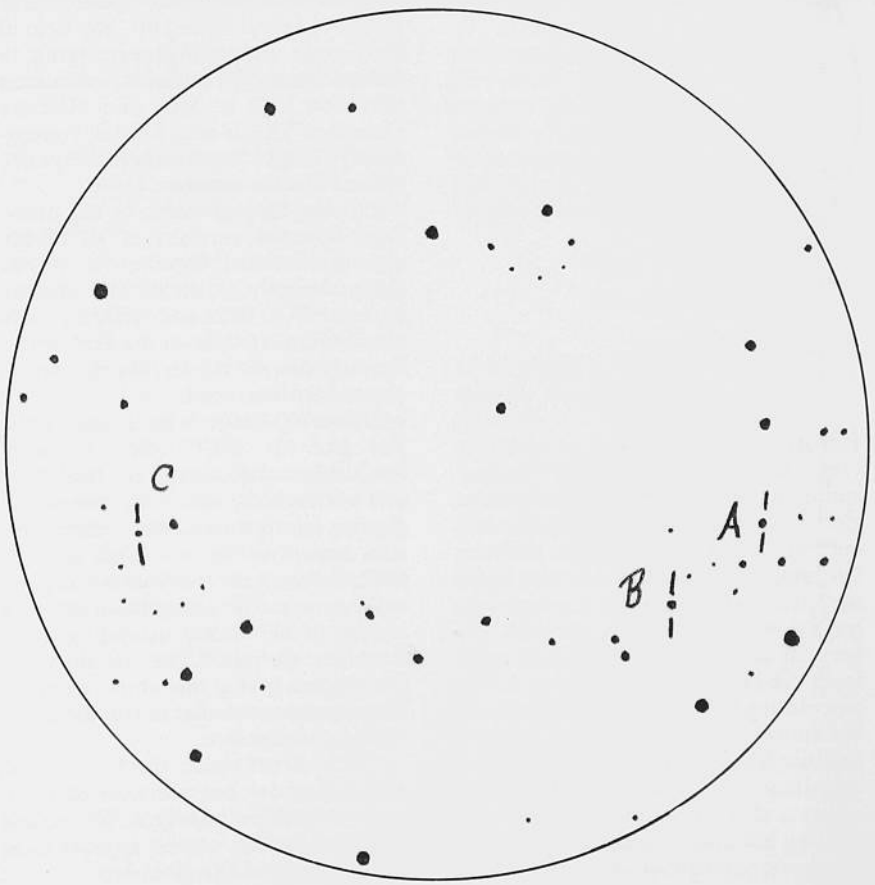
Dear Sir / I read with great interest Jack Marling's article on M7 and its planetaries in the summer *Deep Sky*. In describing Cannon 2-1 (the only one plotted on Tirion's *Sky Atlas 2000.0*), Dr. Marling referred to my observation of the nebula as a "blinking object," which I viewed from Mount Graham with a 20-inch telescope in 1986.

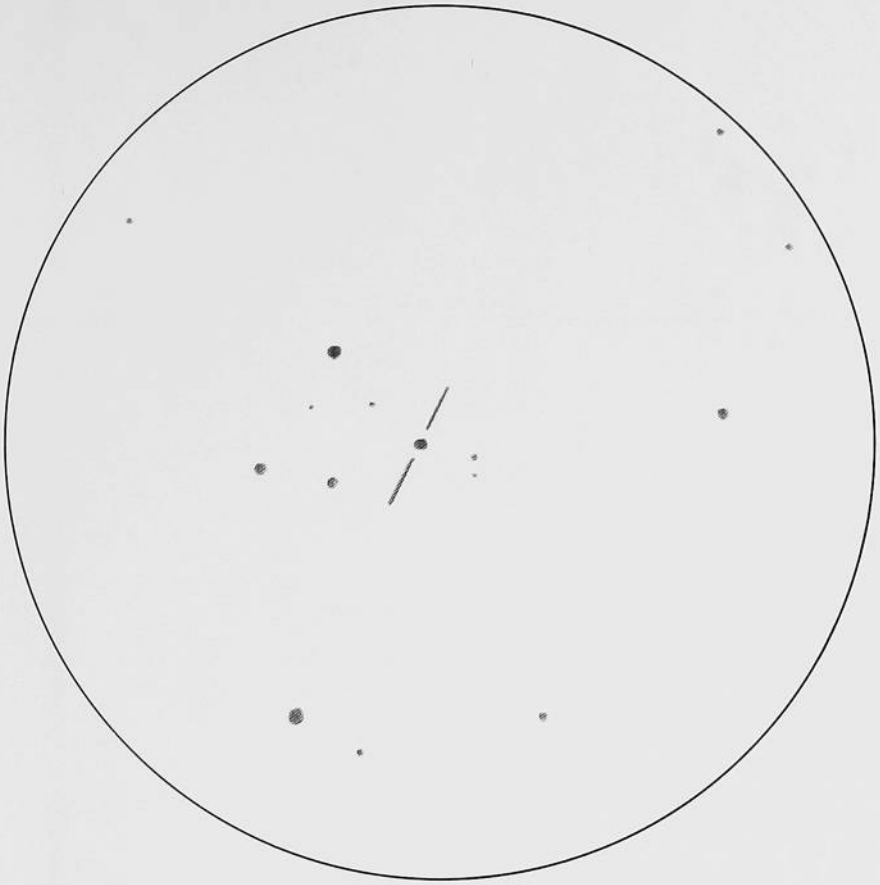
It was soon apparent, however, that we were not talking about the same object! At our club's last star party I carefully located "your" Cn 2-1 in my 14-inch scope and, sure enough, I saw a faint object responding to the UHC filter blinking test, exactly where it was plotted. I estimated its magnitude at about 14 and noted it had a tiny disk with no central star visible.

"My" Cn 2-1 lies about 5' southeast of the other nebula and is much brighter, glowing at about 12th magnitude. This object looks like a star but does respond to the UHC blink test. During moments of good seeing a 2" to

The Cannon 2-1 field sketched by Pierre Schwaar

14-inch f/3.8 telescope at 75x





Cannon 3-1 sketched by Steve Gottlieb

13.1-inch f/4.5 telescope at 144x

3″ disk can be seen with averted vision. By swiftly looking back and forth, one sees star and then nebula so the object resembles the Blinking Planetary in Cygnus, NGC 6826.

Even more curious is the presence of a suspected third nebula about 15′ east, which responds weakly to the blink test but definitely looks fuzzy at high power. Good seeing, large optics, and high powers seem to do the trick with this object.

How many other planetaries might lie in the area? Can other amateurs with large telescopes help check out some of these objects?

Pierre Schwaar
363 East Windsor Avenue
Phoenix, AZ 85004

Two Summer Trapezia

Dear Dave / I want to thank Brian Skiff for his excellent coverage of two summer trapezia in the summer issue. Last night was one of those nights an amateur dreams of, when even the faintest stars are sharp and steady, so I gave myself the challenge of observing Skiff's two star groups.

In 1981 I had drawn both clusters with my old 8-inch SCT, and after checking those old drawings I was surprised at how many stars I saw. But last night with my 11-inch SCT and a 6.7mm Tele Vue eyepiece (418x) both clusters stood out superbly. In IC 4996 even the faint field star above the one Skiff's article labeled "W" was clear, as were most others in the field. The only star in this cluster I didn't see, possibly because of its proximity to star B, was Skiff's star S.

In NGC 6823, though stars 2 and 3 were distinct, I was unable to detect any sign of star 8.

Fr. Lucian J. Kemble, OFM
P.O. Box 430
Cochrane, Alberta
Canada T0L 0W0

Here and There with Planetaries

Dear Dave / In the summer 1988 issue Lucian Kemble's letter raises the question of the identity of the planetary nebula located 1′ west of the 4th-magnitude star Mu (μ) Orionis. This 13th-magnitude planetary was discovered in 1964 by George Abell as he searched through the *Palomar Observatory Sky Survey* (*POSS*). It is designated Abell 12.

While examining the *POSS* recently at UC-Berkeley, I was surprised to find that the image of Abell 12 lies within the overexposed image of Mu Orionis on the blue print. The planetary is only partially visible on the red print. Because Abell 12 has a high surface brightness, high powers can be used to cleanly separate the planetary and light from the star. In addition, a UHC filter significantly dims the overpowering glow from the star.

Discovered in 1955, Abell 33 is another obscure planetary that is easy to locate. It can be found in Hydra at 9h39.1m, −2°48′ (2000). The magnitude-7.2 star SAO 137026 is virtually superimposed on Abell 33's southwestern edge. A 17.5-inch scope and O III filter together show signs of annularity in this object.

Of the recent discoveries, one of my favorites is Sanduleak 2-21, identified in 1975. I estimate this planetary's magnitude as 13.5. Why was such a bright planetary undiscovered for so long? It is located at 8h08.7m, −19°14′ (2000), less than 5′ west of the magnitude-4.4 star 16 Puppis. Its 40″ disk is easily visible in my 13.1-inch scope and an O III filter provides an impressive view. I'd like to think there are still bright planetaries out there somewhere hiding in the glare of bright stars.

On another note, I've enclosed a sketch of the 12th-magnitude planetary Cannon 3-1 mentioned in Phil Harrington's article on Ophiuchus, Serpens, and Scutum. This planetary is unusual because its O III emission is quite weak and it will respond better to blinking with a UHC or Hβ filter.

Steve Gottlieb
1020 Ramona Avenue
Albany, CA 94706

Variable Star Near Stock 2

Dear Sir / I just finished reading the article about Stock 2 in the summer issue of *Deep Sky*. It was a job well done and made for interesting reading. I have been studying this area of sky since 1985 and am always intrigued by new information.

I am particularly interested in the accompanying photograph, as it plainly shows a variable star that was recently discovered by Lennart Dahlmark of France. Mr. Dahlmark announced his find in the *Information Bulletin for Variable Stars* #2878 in 1986. I independently discovered the variable star in 1987 and reported on it in the *Journal* of the American Association of Variable Star Observers (Vol. 16, No. 2). Mr. Dahlmark labeled this star LD103 and noted its position as 1h57m53s, +58°03′ (1950).

Do other amateur astronomers have photographs of this area of sky? They may prove useful to studying the variable star.

Daniel H. Kaiser
2631 Washington Street
Columbus, IN 47201

Off-Season Globular Clusters

by F. Michael Witkoski

Ask a deep-sky observer about his favorite globular clusters and more often than not you'll hear about M13, the Hercules Cluster. Your mind immediately pictures an enormous sphere of stars floating against an infinite deep. At the telescope, your first impression is that "there must be a million stars before me" — which isn't really a bad guess, because most globular clusters contain at least several hundred thousand stars.

A well-placed, outstanding representative of its kind, M13 quickly captures the admiration of one and all. Big and bright and visible during the summer (the season most associated with globulars), M13 sometimes makes us forget that others like it await our gaze.

We could turn to the dazzling constellations of the central Milky Way. Here Ophiuchus, Sagittarius, and Scorpius, which respectively occupy 948, 867, and 497 square degrees, host forty-nine of the 105 NGC globular clusters and sixteen of the twenty-nine Messier globulars. Included in this area, which occupies 5.6 percent of the sky, are half of the globular clusters known. This concentration led Harlow Shapley to conclude in 1917 that the center of our Galaxy lies in this direction.

Although this aggregation suggests that the galactic center and globular clusters are closely associated, the clusters actually form a large halo around the galactic halo. Their apparent nearness results from a projection of three spatial dimensions onto the two-dimensional celestial sphere.

Nearby are M3 and M5, reasonable copies of M13, and just grazing the southern horizon for mid-northern latitude observers is the sky's best globular, Omega Centauri. So many spectacular clusters populate the summer sky that sometimes the beaten path all too constantly beckons us.

Now that this year's globular cluster prime time has passed, we'll be adventurous and explore some not-too-often visited clusters. We'll travel far from the busy mid-galactic activity and enter the realm of off-season globulars, a scattered collection in sharp contrast to the luminaries of summer. While the latter enriches an already distinctive sky, many of the former are beautiful objects in out-of-the-way locations.

It's difficult to pinpoint a "typical" summer or off-season globular. "Typical" summer examples like M13 and M22 in Sagittarius are large and bright. Often their apparent diameters approach 20'. Several are at the threshold of naked-eye visibility and are easy binocular targets. Six- or 8-inch telescopes resolve stars at the edges, if not well in other cases. Dark patches against the cluster's disk and tendrils curving from the circumference are common. A keen-eyed, experienced observer will instantly recognize differences from cluster to cluster.

Globulars away from the Sagittarius-Ophiuchus region are some of the best in the sky.

The common perception of an off-season globular cluster is a dim, unresolvable smudge that requires a large telescope. Size and magnitude are its main descriptive characteristics. Many are only 5' or less in diameter and have magnitudes of 9 or 10.

Of the globular clusters that lie away from the Milky Way (as seen from our position), few lie near the northern circumpolar regions. Of easily visible globulars, NGC 6229 and NGC 6341 (M92), both in Hercules, are the most northern clusters at declinations 47° and 43°, respectively. Only the exceedingly faint Palomar 1 in Cepheus is more northerly at 80°.

Consequently, viewing globulars is a seasonal activity. Although several dim, distant clusters like the fifteen Palomar globulars discovered in recent decades may be within range of large backyard instruments, this article will focus on NGC objects visible from the northern latitudes.

Off-Season Globulars in Autumn

As the so-called autumn void replaces the summer sky, the population of prominent deep-sky objects diminishes rapidly. Only two autumn globulars approach showpiece status, M2 in Aquarius and M15 in Pegasus. Elsewhere the globulars M30 in Capricornus, M56 in Lyra, M71 in Sagitta, and M72 in Aquarius are visible. More of a challenge exists with a handful of NGC globulars scattered over this season's sky.

The eastern corridor of Sagittarius holds several globular clusters. In a lost corner of Sagittarius at the gateway to autumn's sky is the globular cluster **M75** (NGC 6864). About 30° from the hub of the constellation and well beyond the Milky Way boundaries (as outlined on such popular atlases as Tirion and *Skalnate Pleso*), this globular cluster is a loner.

M75 shines at magnitude 8.5 and is a tight cluster measuring 6' across. Although it is within the reach of all but the smallest telescopes, M75 does not easily resolve into stars. In fact, according to William Herschel's scale of globular cluster condensation, where Class I is the most condensed and Class XII the loosest, M75 is a Class I object. It fits the profile of a typical off-season globular cluster.

Not so for **M2** (NGC 7089) and **M15** (NGC 7078). M2 resides about 5° north and less than 0.5° east of Beta Aquarii. Almost 15° due north lies M15. M2 is

Lyra's M56 is a beautiful globular visible during autumn and early winter. Photo by Preston Justis, who used a 10-inch f/6 Newtonian, 103a-O film, and a 40-minute exposure.

a bit larger than M15; their diameters are 12.9′ and 12.3′ respectively. At magnitude 6.4, tied for thirteenth place in the sky, M2 shows a fairly concentrated ball of stars through a modest telescope. Only at its edges can you resolve stars with relative ease. It is a Class II cluster. M15, at magnitude 6.0 (at tenth place), is a bit looser than its counterpart. Herschel saw it as a Class IV object. Not only is M15 the brightest cluster in this survey, it is also astrophysically noteworthy for two reasons. First, it is the only globular cluster known to contain a planetary nebula, 14th-magnitude K 648, discovered spectroscopically in 1927. Lost among thousands of stellar pinpoints, it is impossible to identify visually. But because it is a true cluster member and not merely a foreground object, K 648's uniqueness is significant.

If K 648 is not enough of an oddity, M15 is one of only four globulars that are x-ray sources. The x-radiation results from stellar material streaming from one star of a pair onto the superdense surface of its companion, be it a neutron star, a black hole, or something unknown.

Capricornus epitomizes the autumn void. This constellation covers 414 square degrees, but its brightest star, Delta, glows at only magnitude 2.8. Only two deep-sky objects within the reach of most backyard telescopes lie within Capricornus. They are NGC 6907, an isolated 12th-magnitude galaxy, and the globular cluster **M30** (NGC 7099).

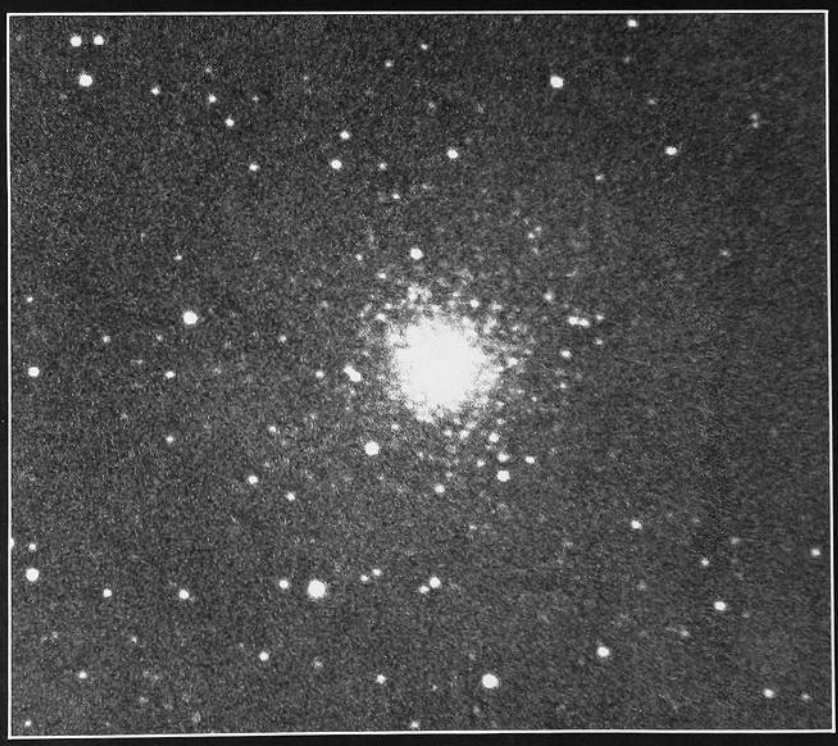
At a respectable magnitude of 7.3, M30 ranks thirtieth in the sky. It is easy to locate, because it lies less than half a degree west of the naked-eye star 41 Capricorni. A pair of binoculars will show fuzziness, and any telescope will reveal its nature.

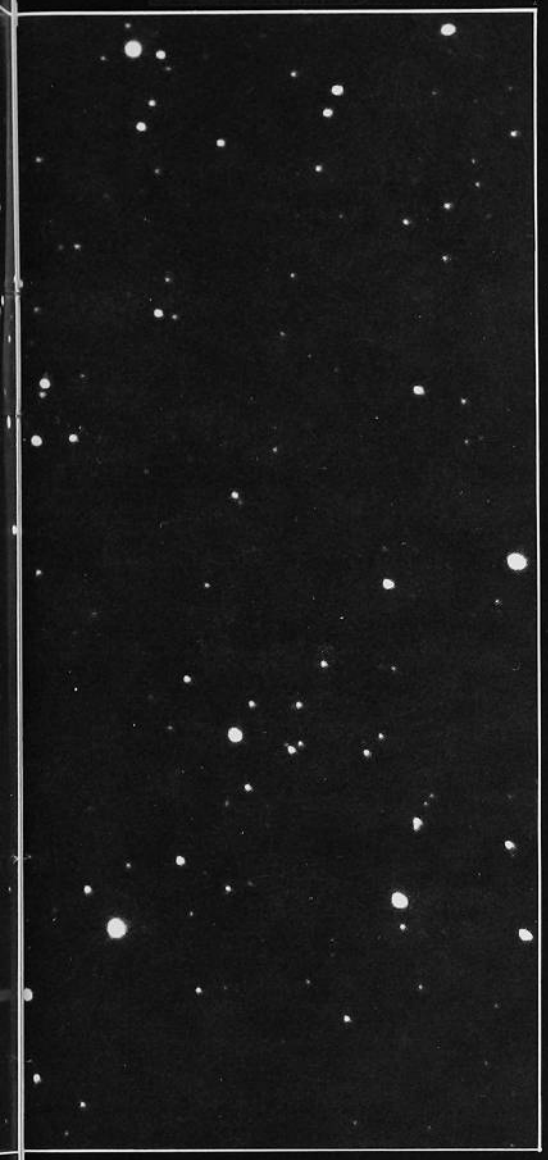
M30 has the dubious distinction of being the only Messier object not visible during most Messier Marathons. During these late March, dusk-to-dawn observing sessions all other M-objects are visible over the course of the night.

Lyra is a very different constellation from Capricornus. It is small yet rich in stars and lies just outside the Milky Way mainstream. It contains various noteworthy stellar and deep-sky objects. It is the home if Vega, the fifth brightest star; M57, the famous Ring Nebula; and the celebrated double star Epsilon Lyrae.

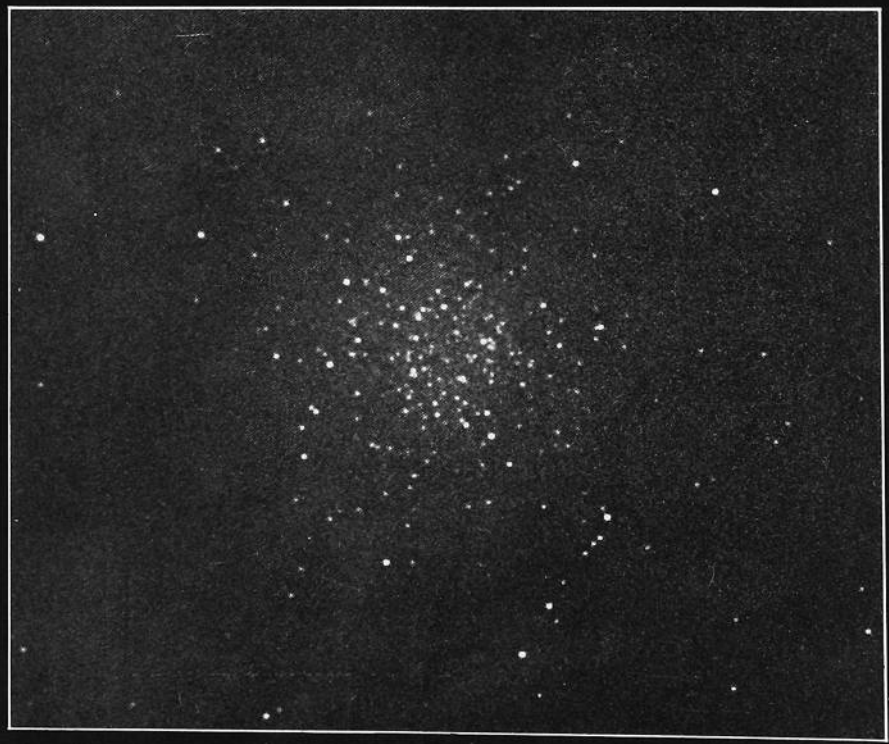
Overshadowed is the globular cluster **M56** (NGC 6779). It is nearly midway between Gamma Lyrae and Albireo, the well-known double star in Cygnus. At magnitude 8.3, M56 is a bright object. It is also a fairly loose globular that falls into Class X.

Across the Milky Way from Lyra is star-rich Sagitta, the third smallest constellation. Its prominent arrow shape is





Top left: *NGC 2419 in Lynx is one of the remotest globulars visible in small scopes. Photo by Tom Eby, who used an 8-inch SCT at f/5.6 and hypered Tech Pan film.*
Above: *M15 in Pegasus is the only globular known to contain a planetary nebula. Lee C. Coombs used a 10-inch f/5 Newtonian, 103a-O film, and a 10-minute exposure.*
Below: *Difficult in small telescopes, NGC 5466 in Bootes is a sprinkling of faint stars. Photo by Martin C. Germano, who used an 8-inch f/10 SCT, 103a-F film, and a 60-minute exposure.*
Below center: *NGC 5053 in Coma Berenices is a challenging object for small scopes because of its low surface brightness. Photo by Tom Dessert, who used a 10-inch f/6 Newtonian, 103a-O film, and a 20-minute exposure.*
Below left: *Far away from the galactic center in eastern Sagittarius lies M75. Martin C. Germano photographed the cluster with an 8-inch f/10 SCT, 103a-F film, and a 50-minute exposure.*



Off-Season Globulars

NGC	Name	Herschel	R.A. (2000.0)	Dec. (2000.0)	Con.	Diam.	Mag. (V)	Dist. ⊙	Dist. GC	Notes of Interest
288	H 20[6]	X	0h52.8m	−26° 35′	Sculptor	13.8	8.1	8.2	12.1	Near SGP
1049					Fornax		12.6			Extragalactic
1851	Dun 508		5h14.1m	−40°03′	Columba	11.0	7.2	12.0	17.2	
1904	M79	V	5h24.5m	−24°33′	Lepus	8.7	7.8	13.0	19.5	
2298		VI	6h49.0m	−36°00′	Puppis	6.8	9.2	10.6	16.2	
2419			7h38.1m	+38°53′	Lynx	4.1	10.3	91.4	99.4	Very distant
4147	H 19[1]		12h10.1m	+18°33′	Coma Berenices	4.0	10.2	17.3	19.9	
4590	M68	X	12h39.5m	−26°45′	Hydra	12.0	7.7	9.6	10.1	
5024	M53	V	13h12.9m	+18°10′	Coma Berenices	12.6	7.5	18.5	19.2	
5053			13h16.4m	+17°42′	Coma Berenices	10.5	9.9	15.8	16.7	Very sparse
5466	H 96	XII	14h05.5m	+28°32′	Bootes	11.0	9.0	15.8	16.4	
5634	H 70[1]	IV	14h29.6m	−5°59′	Virgo	4.9	9.4	25.0	20.7	
5694			14h39.6m	−26°32′	Hydra	3.6	9.2	31.3	25.4	
6779	M56	X	19h16.6m	+30°11′	Lyra	7.1	8.3	9.8	9.8	
6838	M71		19h53.8m	+18°47′	Sagitta	7.2	8.0	4.4	7.4	Very near
6864	M75	I	20h06.1m	−21°55′	Sagittarius	6.0	8.5	18.5	12.0	
6934		VIII	20h34.2m	+7°24′	Delphinus	5.9	8.7	14.9	12.1	
6981	M72	IX	20h53.5m	−12°32′	Aquarius	5.9	9.3	17.0	12.7	
7006		I	21h01.5m	+16°11′	Delphinus	2.8	10.5	39.1	36.3	Distant
7078	M15	IV	21h30.0m	+12°10′	Pegasus	12.3	6.0	9.7	10.4	Contains planetary
7089	M2	II	21h33.5m	−0°49′	Aquarius	12.9	6.4	11.9	10.9	
7099	M30	V	21h40.4m	−23°11′	Capricornus	11.0	7.3	7.2	7.2	
7492		XII	23h08.4m	−15°37′	Aquarius	6.2	11.4	19.1	18.7	Very challenging

NGC: Designation in *New General Catalogue.* **Name:** Other designation. **Herschel:** Herschel concentration class, where I is densest and XII loosest. **R.A.:** Right ascension; **Dec.:** Declination, both in equinox 2000.0 coordinates. **Con.:** Constellation in which object lies. **Diam.:** Diameter in arcminutes. **Mag. V:** V magnitude. **Dist. = ⊙:** Distance between cluster and the Sun in kiloparsecs. **Dist. GC:** Distance between cluster and galactic center in kiloparsecs.

outlined by four equally bright stars. Midway between Gamma and Delta is **M71** (NGC 6838), a medium-sized cluster of magnitude 8.0. Many old charts label M71 as an open cluster, and Herschel did not recognize it as a globular, but twentieth-century studies have confirmed its identity.

M71 is the nearest globular in our survey at 4.4 kiloparsecs. If M71 were comparably distant to most others we will cover, it would be beyond the range of many backyard telescopes. It is overshadowed by the bright, nearby planetary nebula, M27, the Dumbbell in Vulpecula, much the way M56 suffers from M57's proximity.

The remaining autumn Messier globular is **M72** (NGC 6981), a resident of Aquarius. Three and a half degrees south of 5th-magnitude Mu Aquarii and less than a degree east of a 6th-magnitude star, it is conveniently located. It is also about a degree west of M73, an asterism of four stars, the most anomalistic Messier object. M72's magnitude of 9.3 makes it the dimmest Messier globular, although a 3-inch telescope shows it easily. This cluster is not very concentrated — Class X — yet its stars stubbornly resist resolution. Few are brighter than 16th magnitude.

Delphinus, a small yet conspicuous constellation just east of Sagitta, is home to two diminutive globulars. **NGC 6934** is 4° due south of Epsilon Delphini, and **NGC 7006** is 3.5° due east of the attractive double star Gamma Delphini.

NGC 6934 is larger and brighter than its counterpart: 5.9′ versus 2.8′ and magnitude 8.7 versus magnitude 10.5. NGC 6934 is a fairly loose Class VIII cluster, whereas NGC 7006 is a tight Class I.

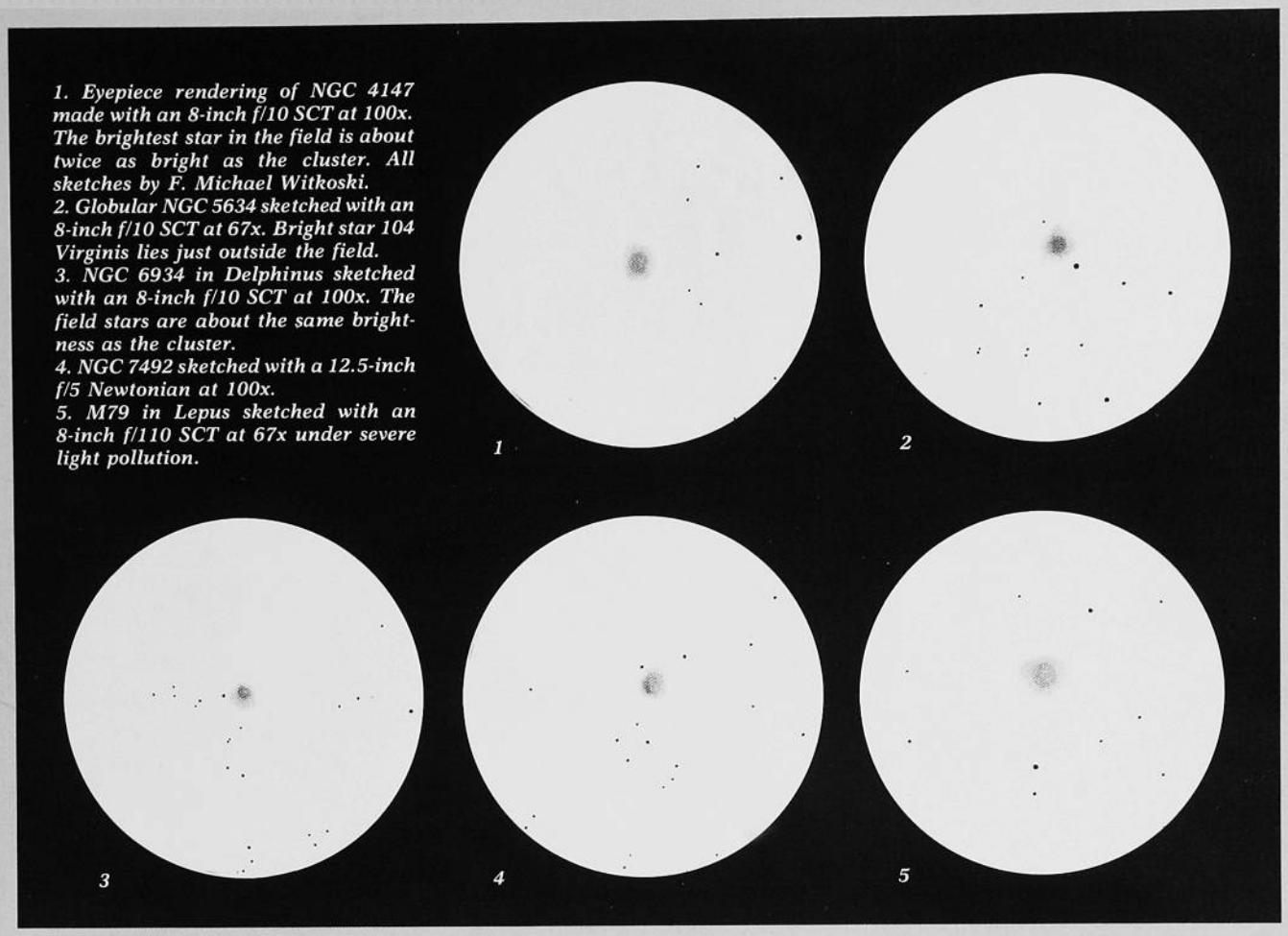
NGC 7006 is among the most distant globular clusters within range of a portable telescope. Its distance is 39.1 kiloparsecs, nearly three times that of NGC 6934. By comparison, NGC 6397, the closest globular cluster, is only 2.2 kiloparsecs away. (This object in the constellation Ara is too far south for northern observers.) NGC 7006 and NGC 6934 are 36.3 and 12.1 kiloparsecs from the galactic center, respectively.

Our next stop is **NGC 288**, a loose (Class X) cluster at magnitude 8.1. It resides in Sculptor, a nondescript southern constellation. NGC 288 is less than a degree northeast and is the closest NGC object to the south galactic pole. Because its declination is −27°, NGC 288 is visible from northern latitudes only a few hours per night at most. Late September at midnight or mid-November at about 9 p.m. are ideal times.

Haze or light pollution could be a problem for finding NGC 288, but under good transparency, NGC 288 shows up in 6-inch and larger telescopes. It is about 2° southeast of the bright spiral galaxy NGC 253. If your view of NGC 253 seems sharp, NGC 288 should afford a respectable view. But if you can't see NGC 253, then the globular won't be visible either. The quickest route to NGC 288 begins at the isolated 2nd-magnitude star Beta Ceti. Heading south 8° and east less than a degree will bring you to NGC 253. From there the cluster is just a hop away. Two similar triangles of stars easily visible through a finder scope mark intermediate steps from Beta Ceti to the Galaxy.

The most challenging Milky Way globular in the spring sky is Aquarius' **NGC 7492**. It is a 6.2′-diameter, loose (Class VII) cluster with a magnitude of 11.4. Of NGC globulars, only NGC 6749 in Aquila and NGC 1049, a member of the dwarf galaxy in Fornax, are dimmer. NGC 7492 lies about 4° east of the bright star Delta Aquarii. But despite this convenient reference, the cluster is easy to overlook. It appears as no more than a smudge through instruments as large as 12.5 and 14 inches in aperture. The surrounding field of view consists of two dozen equally faint stars. Simply speaking, nothing stands out here — NGC 7492 is an object that tests the best of telescopes.

NGC 1049 is also a difficult object. Although a member of another galaxy, the cluster's concentrated nucleus



1. Eyepiece rendering of NGC 4147 made with an 8-inch f/10 SCT at 100x. The brightest star in the field is about twice as bright as the cluster. All sketches by F. Michael Witkoski.
2. Globular NGC 5634 sketched with an 8-inch f/10 SCT at 67x. Bright star 104 Virginis lies just outside the field.
3. NGC 6934 in Delphinus sketched with an 8-inch f/10 SCT at 100x. The field stars are about the same brightness as the cluster.
4. NGC 7492 sketched with a 12.5-inch f/5 Newtonian at 100x.
5. M79 in Lepus sketched with an 8-inch f/110 SCT at 67x under severe light pollution.

allows NGC 1049 to be viewed even if the low surface brightness parent galaxy is invisible. In fact, the galaxy itself was discovered only in 1938. Spreading over a degree and visible only as a slight brightening on photographic plates, it is impossible to view the Fornax dwarf visually. With a diameter of 25′, NGC 1049 shows in a telescope as small as 8 inches if conditions are superb.

NGC 1049's southerly declination, −34°, is a serious obstacle for northern observers. From a location where the cluster rises far above the horizon, such as the Caribbean, it would probably show at least as well as NGC 7492. Five other globulars inhabit the Fornax System, but they were not included in the *NGC*.

Winter's Globular Clusters

Our first winter stop is the constellation Lepus the Rabbit, target of Orion's hunt. The brightest deep-sky object here is globular cluster **M79** (NGC 1904). Although not overwhelmingly bright, M79's magnitude of 7.8 and medium condensation — Class V — place it within easy reach of small telescopes and large binoculars. Its declination of −25°, however, may limit the view for northern observers if conditions are less than ideal. Moderate light pollution definitely affects M79, but against a dark sky it shows up quite well.

South of Lepus is Columba, where the overlooked cluster **NGC 1851** awaits. Its magnitude of 7.2 places this cluster in a respectable twenty-fifth position among all globulars. Only half of Messier's globulars are brighter. Unfortunately, lying in an out-of-the-way corner of a little-known constellation adversely affects NGC 1851's popularity. Nevertheless, it is well worth the perseverance you may need to find it.

We could compare a search for NGC 1851 with one for **Omega Centauri** (NGC 5139), a springtime object 7° farther south. Assuming we are at the northernmost latitude from which Omega is visible, i.e., northern continental United States, what can we expect? Its contrast with the horizon will be mediocre at best, and it will appear like a dim giant.

Usually a 4-inch telescope is necessary to see Omega. Its brighter magnitude (3.5 more than NGC 1851's) simply cannot compete with the layers of atmosphere through which its light must pass, whereas on a dark, steady night the smaller and dimmer underdog can take full advantage of its few precious degrees in clearer sky and shine through for northern observers.

Another challenge awaits you in Puppis. Here lies a small, dim (magnitude 9.2) globular, **NGC 2298**. At declination −36, it is nearly as far south as NGC 1851, but with less impressive credentials it is much more difficult to see.

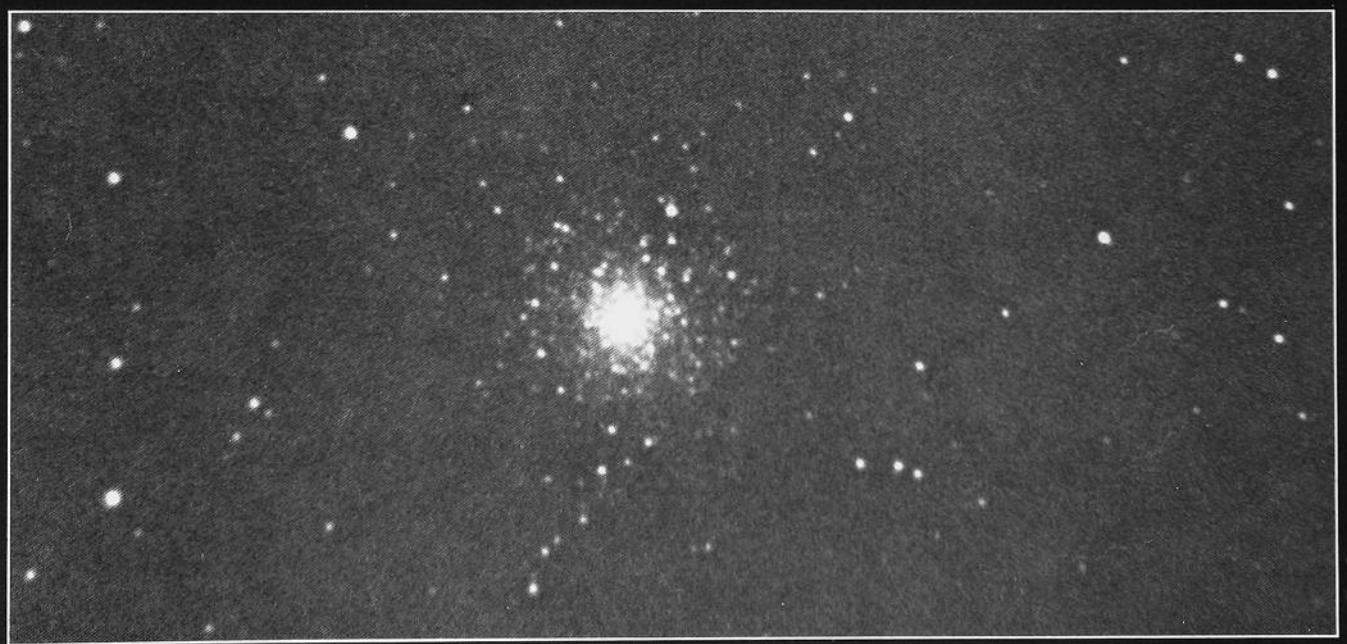
Over the millennia mankind has witnessed radical changes in his perception of the cosmos. Heliocentricity and the expanding universe are among the best known and most far reaching of these changes.

A revelation — not necessarily a headline grabber — in the late 1970s that galaxies are actually much more massive and extensive than their visible light indicates has once again changed our concept of the cosmos. No longer is the Milky Way a disk a mere 30 kiloparsecs across. Its outer extent could exceed ten times that figure. The case is similar for other great spirals. The Andromeda Galaxy, which has boundaries that have always been ambiguous, stretches many diameters beyond its bright disk.

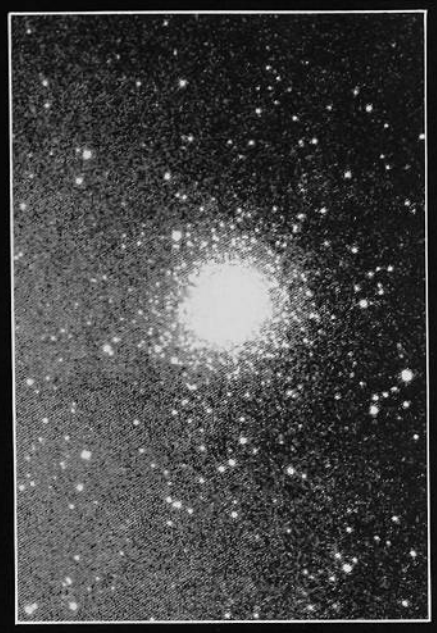
How does all this concern off-season globular clusters? Certainly, it is not too relevant to most of the clusters we have looked at so far. But to **NGC 2419**, an inconspicuous object in the bleak constellation Lynx, it is all-important.

NGC 2419 is a meager globular riding high in the cold winter sky. This object is small and dim (magnitude 10.3). It has no Herschel globular cluster classification, because it wasn't recognized by Herschel as a cluster.

The reason for NGC 2419's dimness is that the object is distant. At 99.4 kilo-



Top: *Hydra's M68 is a bright, loose cluster easily visible in small telescopes. Photo by Jack Metcalfe, who used an 8-inch f/10 SCT, hypered Tech Pan, and a 25-minute exposure.*
Above: *M79 in Lepus is one of the only prominent winter globular clusters. Photo by Martin C. Germano, who used an 8-inch f/10 SCT, 103a-F film, and a 60-minute exposure.*
Top right: *Aquarius' M2 is a tight cluster difficult to resolve in backyard telescopes. Photo by Lee C. Coombs, who used a 10-inch f/5 Newtonian, 103aO film, and a 10-minute exposure.*
Right center: *M71 in Sagitta is so loose that for years astronomers thought it was an open cluster. Photo by Preston Justis, who used a 10-inch f/6 Newtonian, 103a-F film, and a 60-minute exposure.*
Bottom right: *NGC 6934 in Delphinus is a challenging object to resolve for small scope users. Photo by Preston Justis, who used a 10-inch f/6 Newtonian, 103a-O film, and a 70-minute exposure.*



parsecs from the galactic center and 91.4 kiloparsecs from us, it is by far the most remote NGC globular in our Galaxy. It is more than twice the distance of Delphinus' NGC 7006.

According to the "old" picture of the limit of the Galaxy, NGC 2419 would have been an outlying member. Speculation that NGC 2419 was an intergalactic cluster was common. Now it is simply regarded as one of the more distant visible components of our Milky Way. In fact, of the fifteen Palomar globulars, only one, Palomar 4, is farther away at 93.3 kiloparsecs.

To see NGC 2419, you need at least a 4-inch telescope. With this aperture the cluster resembles a hazy star. Only with larger instruments does it become apparent that a globular cluster is in view. But at the enormous distance of NGC 2419, no details are discernible. More important is the realization that one is observing a special celestial object.

Globular Clusters of Spring

Springtime globular clusters can be observed in four constellations. Although not as bright as the autumn clusters, these objects offer a great deal to small-telescope users.

NGC 4147 is a tantalizingly dim globular cluster lost in a sea of galaxies. Leo, Ursa Major, Canes Venatici, Virgo, and NGC 4147's home of Coma Berenices abound in galaxies.

At magnitude 10.2 this small cluster is among the most difficult in our entire survey. Although its apparent brightness compares with that of NGC 1049, in absolute terms there is no match. NGC 4147 is simply smaller and closer.

An observer familiar with galaxy hopping in this area can easily learn the route to NGC 4147. The 5th-magnitude star 11 Comae Berenices is a logical starting point. You need only center a telescope here and shift about a degree north. The galaxy NGC 4293 will be in the field. From here the cluster is 2.5° west. Realistically a 6-inch telescope is the smallest suitable instrument for this cluster.

Elsewhere in Coma Berenices are **NGC 5053** and **M53** (NGC 5024). Both are near 4th-magnitude 42 Comae Berenices: NGC 5053 is about 1.5° due east, M53 is about a degree northeast. A wide-field eyepiece will show both clusters. The similarity in size and contrast in concentration makes this a most unusual pair of globular clusters. While M53 is a respectable 7.5 magnitude and somewhat concentrated Class V, its counterpart is a tiny, loose cluster. Yet the diameters of for M53 and NGC 5053 are 12.6′ and 10.5′, respectively.

A pair of globular clusters, **M68** (NGC 4590) and **NGC 5694**, reside in Hydra, the largest constellation in the sky. Because this giant contains few bright stars, observers often overlook it. By association, its two globulars are not among the best known. Compounding this is their southerly declination, −26°, and most favorable positioning in springtime when nights are short. Nevertheless, observers who make the best of their time will find this pair rewarding.

About 0.5° northeast of a 5th-magnitude star that lies about 4° south of Beta, the southeast star in the main outline in Corvus, is M68. It is fairly loose (Class X) and average in brightness (magnitude 7.7) and size (12′) for a Messier globular. Almost 30° due east is the somewhat dimmer (9.2 magnitude) NGC 5694. It is small and distant: 31.3 kiloparsecs from us and 25.4 kiloparsecs from the galactic center. Of the clusters in the Milky Way covered in this article, only NGC 2419 and NGC 7006 are more distant.

Virgo is the second largest constellation and overflows with galaxies. So dense is the celebrated Virgo Cluster in the western portion that it is a veritable cartographer's nightmare. In addition, the eastern portion of Virgo is rich in galaxies, although far overshadowed by the Virgo Cluster. Of the 211 objects listed in *Burnham*, the only nongalaxy is **NGC 5634**, a globular cluster. It is 3° east of Iota, or 99 Virginis and 4° south of Phi, or 105 Virginis. Its distance is 25 kiloparsecs, which makes it the fourth most distant cluster in this article. Because of this, it shines at only magnitude 9.4, less than one tenth of a magnitude dimmer than M72, the dimmest Messier globular.

Nevertheless, this cluster is among the brightest deep-sky objects in Virgo. Only the galaxy M104 is conclusively brighter.

NGC 5466 in Bootes is the final stop. This dim cluster is quite spread out and has no instant reference points, although the spectacular globular cluster M3 is nearby. M3 lies midway along a 26° diagonal from Arcturus to Alpha Canum Venaticorum and, despite its brightness, sometimes requires effort to locate. NGC 5466 is a mere 5° east.

Although it is closer in the summer sky then M3, NGC 5466 has been included because it typifies the challenge of the off-season globular cluster.

When we observe a globular cluster, we see a structure nearly as old as the universe itself. Although our Galaxy itself must be at least as old as its globular clusters, it is in a state of constant flux. The same is not so for the globulars, long established and stabilized. Because their elongated orbits keep them away from interaction with other matter, they will remain intact for billions of years to come.

Mike Witkoski is a frequent contributor to Deep Sky.

The Challenge of Schmidt Camera Astrophotography

by Rick Dilsizian

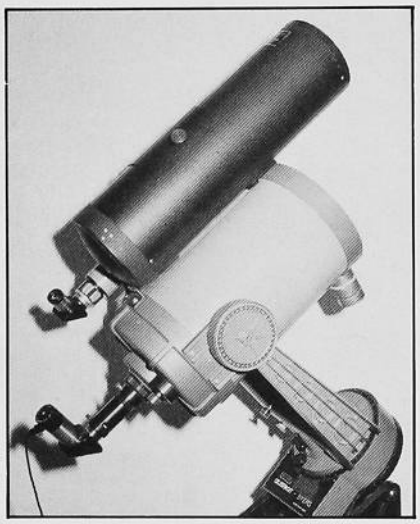
At first glance, a Schmidt camera almost looks like a Schmidt-Cassegrain telescope. However, you can't look through a Schmidt camera and photograph large areas of sky. A Schmidt camera lets you record large areas of sky with short exposures. Sounds great? Then you should know that handling a Schmidt camera is a tricky job.
should know that handling a Schmidt camera is a tricky job.

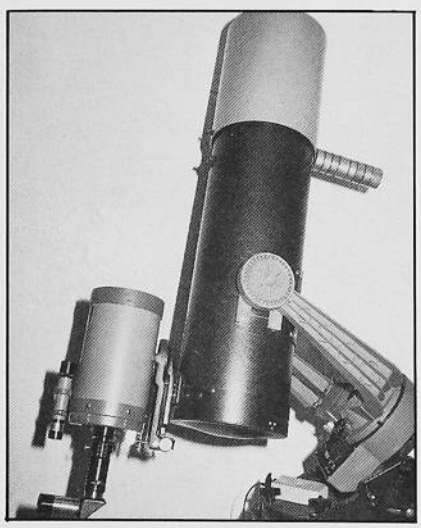
The major advantages of the Schmidt camera are its speed and resolution. Schmidt cameras enjoy fast photographic speeds (f/1.5 to f/2.5) that limit exposures to 3-15 minutes. Compare this with exposure times fifteen times as slow with prime focus and you can see why they are popular. "Well," you might ask, "what about coma?" Schmidt cameras are designed so they have razor sharp images across the entire film plane without distortion. This results from the optical design of the system.

What about resolution? Coupled with an extremely fine-grained, high-resolution film like 2415, Schmidt cameras produce wide-angle, high-resolution photographs of the night sky, capable of extreme (up to 50x) enlargement. Think of the Schmidt camera as an extremely fast 200mm-300mm telephoto lens with a theoretical resolution surpassing 1,000 lines/mm.

Development of the Schmidt Camera

The Schmidt camera was developed in 1931 by Bernhard Schmidt (1879-1935), a German optical designer. The original camera's components included a long tube with a mirror at the back end and a transparent corrector plate at the front end. A film holder was placed at the prime focus of the system some distance between the mirror and the corrector plate. By using a spherical mirror and then curving the corrector plate at the front in a certain fashion, Schmidt was able to eliminate not only coma and astigmatism but also spherical aberration. And by curving the photographic film holder, each point on the film plane would be in perfect focus. By doing this Schmidt made a fast, high-resolution, distortion-free system.





Top: A 5.5-inch f/1.65 Schmidt camera mounted on an 8-inch f/10 SCT. The telescope is used for guiding. Above: An 8-inch f/1.5 Schmidt camera with a 5-inch SCT guide telescope. The coupler allows freedom of guide star selection. Photos by Rick Dilsizian. Left: The Rho Ophiuchi region photographed with an 8-inch f/1.5 Schmidt camera. Mace Hooley exposed Tech Pan film for 12 minutes.

Why Buy a Schmidt Camera

Today Schmidt cameras are commercially available. However, one costs as much as a good Schmidt-Cassegrain telescope. If you're serious about astrophotography, a Schmidt camera might be a good investment. Who wants to stay outside for forty minutes to photograph M42 on a winter's night? With a Schmidt camera, that time drops to three to five minutes.

There are other reasons to consider owning a Schmidt camera. Large objects are dramatically captured by the Schmidt camera. You can't photograph the North America Nebula, the entire Andromeda Galaxy, or the delicate nebulosity surrounding all of the stars of the Pleiades at prime focus with an 8-inch SCT. You can't capture both the Lagoon and Trifid nebulae on the same negative with a normal telescope. Or the vast clusters of galaxies in Virgo or Coma Berenices. And the list goes on.

One of the greatest advantages of the Schmidt camera is that it is prefocused! You don't have to (and indeed *can't*) focus your shot. That's a real blessing because most astrophotographers have focus problems with prime-focus astrophotography. The Schmidt camera's focus is fixed so you don't have to worry about it.

Disadvantages of Schmidt Cameras

Of course, advantage becomes disadvantage if you try to photograph small objects. You can't get a good photo of the Ring Nebula, Jupiter, or Saturn with a Schmidt camera. The image scale is too small. The principal rule is that if the object you are trying to photograph is less than 10' in diameter, forget it.

A second disadvantage of Schmidt camera photography is that there is no commercially available shutter for the

Delicate shades of nebulosity glow in a photo of emission region IC 1396 in Cepheus. J. A. Farrell used a 7.5-inch Schmidt camera, 103a-E film, and a 15-minute exposure.

Schmidt shots with Tech Pan allow extreme enlargements: this photo of M22 has been enlarged twenty times. Photo by Rick Dilsizian.

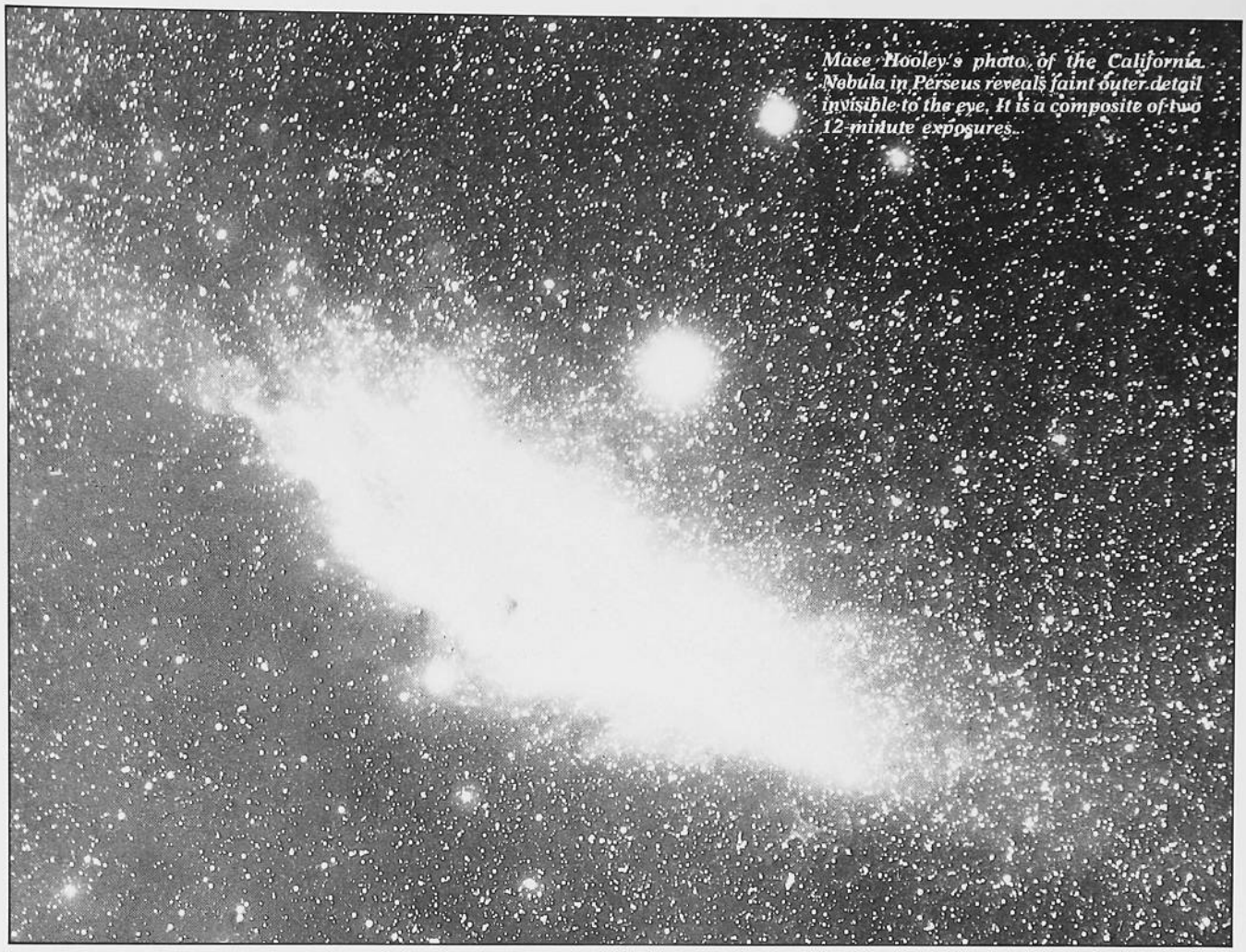
Five minutes of exposure are enough to capture the faint outer nebulosity surrounding Orion's M42. Eight-inch Schmidt photo by Rick Dilsizian.

The Pleiades show considerable reflection nebulosity in this photograph made with an 8-inch f/1.5 Schmidt camera. Photo by Rick Dilsizian.

Schmidt cameras are efficient recorders of stars. Open cluster M23 in Sagittarius is recognizable in this short-exposure 8-inch Schmidt photo by Rick Dilsizian.

Large galaxies are among the Schmidt's best targets. M31 and its companions M32 and NGC 205 show well in this 16-minute exposure made with an 8-inch Schmidt. Photo by Rick Dilsizian.

The North America and Pelican nebulae glow spectacularly in an 8-inch Schmidt photo of only a few minutes' exposure. Photo by Rick Dilsizian.



Mace Hooley's photo of the California Nebula in Perseus reveals faint outer detail invisible to the eye. It is a composite of two 12-minute exposures.

A Typical Schmidt Camera Exposure

Let's say that you are going to photograph a region centered on the Orion Nebula with a Schmidt camera. The following steps outline each phase of the procedure.

1. Compose the frame by picking a suitable guide star in the field you want to photograph. Because you can't see the area with a Schmidt camera, you will have to "align" the camera's field with that of the guide scope. Move the guide star into the center of your illuminated reticle.
2. Orient the cross hairs of the illuminated reticle in the following way:

a. Turn off the motor drive and allow the guide star to drift across the field. Orient one of the cross hairs to match the direction of this drift.

b. This cross hair will now help you monitor right ascension. The cross hair perpendicular to this one will show declination drift.

c. Turn the motor drive back on.

3. Next, load one frame of film into the Schmidt film holder. Don't be intimidated, just be careful not to scratch the film as it runs over the inner surface of the film holder. Follow the itemized steps below, in the dark.

a. Advance the film through the holder with the curved backing plate removed. Keep the film centered between the edges of the film holder with your thumb and forefinger (it takes some practice!).

b. Once the film is through, insert the curved backing plate and tighten.

c. Cut the film at both ends with scissors. Cover the holder with the supplied cap to prevent light leakage before you insert the film holder into the camera. A helpful hint: I put the loaded film holder into an empty 100-foot film roll canister, cap down, to prevent accidental exposure. You may be able to pick up these canisters at your favorite photo supply store.

4. Make sure the shutter, a piece of cardboard, is in front of the corrector lens.
5. Load the camera with the film holder. The receiving assembly on the camera is magnetic and will orient the holder properly. Be careful to gently snap it into place without dropping it!
6. By now the guide star will have drifted from the center of the reticle but should still be someplace in your eyepiece's field of view. Recenter the guide star.
7. Remove the cardboard to start the exposure. Don't let the guide star drift. Remember the camera is extremely fast and will record slight tracking errors faster than a prime-focus system.
8. To stop the exposure, place the cardboard in front of the corrector lens. Remove the film holder and return to the dark area where you loaded the film.
9. Remove the film in the following manner to eliminate scratches on it.

a. Loosen the curved backing plate and slide it out while keeping one thumb and forefinger on the film. This prevents the film from moving (and getting scratched) while you remove the major pressure source.

b. Now move the film to the center of the film holder, away from its sides, and slide it out. This prevents the film from scratching the sides of the film holder itself.

c. Place the film in the film canister. Obtain another canister for another exposure. By placing only one exposed frame in the canister, you are giving it room to prevent scratching against the sides of a more crowded container.

10. You're now ready for another exposure!

The Rosette Nebula and star cluster NGC 2244 are nearly overexposed in a 12-minute exposure made with an 8-inch Schmidt. Mace Hooley photo.

instrument. You can either try to build one or have somebody holding an opaque piece of cardboard act as your shutter. (With a small Schmidt camera you can hold the cardboard yourself.)

A third disadvantage is that each 35mm frame of film must be loaded directly into the instrument, exposed, and then stored for future processing. This demands two things: (1) you must load and unload the film in total darkness and (2) you must process the film yourself. These days it isn't hard to process film — Kodak and other companies have commercially available kits for both black-and-white and color work (both color negatives and slides).

Some Schmidt cameras have the availability of roll film holders that accommodate an entire roll of film. You take one exposure, then advance the film and take the next. This is a great convenience, but it is easy to scratch the film using one of these.

Equipment for Schmidt Camera Photography

Okay. You've decided the Schmidt camera is for you. Before you get in deeper, consider the accessories you'll need.

1. The Schmidt camera.
2. A guide telescope with motor drive.
3. A drive corrector.
4. A guiding eyepiece with illuminated cross hairs.
5. An opaque piece of cardboard to act as a shutter.
6. An adjustable stool for comfort while taking the exposure.

The motor drive and drive corrector are used to provide perfect tracking. To do this, you'll keep a guide star centered in the illuminated reticle eyepiece.

The cardboard serves as a shutter. Once the film is loaded into the film holder, place the cardboard in front of the corrector lens to block all incoming light. Then insert the film holder in its place in the camera and center a guide star in the illuminated reticle. At this point remove the cardboard from the front of the corrector lens. This starts the exposure. When you're finished, the cardboard is placed in front of the corrector lens, stopping the exposure.

The Concept of Guiding Ratio

"Guiding ratio" simply means "what you see is what you get." If your guiding is poor, your astrophoto will probably have trailed images. So the plan of attack should be to guide at the highest magnification possible and make corrections in right ascension and declination drift the instant they occur. By guiding at high magnification, you significantly reduce the possibility of trailed images because you see small drifts before they register on the film.

The guiding ratio is the effective guiding focal length divided by the focal length of the camera (usually either 225mm or 300mm). Let's say we are using a small (225mm focal length) Schmidt camera piggybacked on top of an 8-inch SCT (2,000mm focal length). A normal 12mm illuminated reticle used as the guiding eyepiece would produce an effective focal length of 8,250mm. This means that the guiding ratio would be

8250/225 or 36.67.

A 5-inch SCT guidescope (250mm focal length) piggybacked on a large Schmidt camera (300mm focal length) with the same guiding eyepiece (12mm — system focal length of 5250mm) would yield a guiding ratio of

5250/300 or 17.50.

To increase this ratio even higher, use a 2x Barlow lens in the system. The guiding ratio now increases by a factor of two, providing 73.34 and 35, respectively. A guiding ratio approaching 30 will pinpoint star images.

Films and Exposure Times

Because Schmidt cameras are extremely fast (f/1.5 and f/1.65 for two commercial models), slow, fine-grained films can be used without long exposure times. For black-and-white work, the standard is hypersensitized Tech Pan 2415. Exposure times vary with sky conditions and the object's altitude above the horizon. From a suburban site with a limiting visual magnitude of 5 at the zenith, the following exposure times can be used for astrophotography at the meridian:

Dec. of Object	Exposure
−40° to 0°	3-5 minutes
0° to +20°	5-10 minutes
+20° or greater	10-15 minutes

For color work, I use either Fujichrome RD50 or RD100, gas hypered and processed as a color negative using C-41 chemistry. Both films are extremely fine-grained and yet yield high-contrast images when processed as a color negative. In addition, you can produce a black sky with color filtration when making either enlargements or duplicate slides from color negatives. The slower of the two (Fujichrome RF50) is best for capturing star clusters because its resolving power is high. Emission nebulae, galaxies, and large planetary nebulae require greater film speed; they show up well on Fujichrome RD100.

The exposure times for Fujichrome RD100 are approximately the same values presented above. You should experiment in your own sky to see if you can expose longer. If you are in a light-polluted area, you will have to keep exposures short to eliminate sky fogging. Use the times above as a start and work from there. For RD50, you can probably lengthen the times by a factor of 1.5.

I normally either process prints directly from color negatives or make slides from the Fujichrome color negatives using of Kodak 5072 Vericolor Slide Film and a slide duplicator. The details of this process (color and black-and-white processing papers, and filtration) will be described in a future *Deep Sky*.

Schmidt cameras are expensive, but the quality of the images they produce far surpasses that of any other instrument for extended deep-sky objects. What more could a deep-sky photographer want?

Rick Dilsizian is an expert astrophotographer who lives in Mahopec, New York. This is his third article in a series on deep-sky photography.

Profile of a Deep-Sky Sketcher

by Gregg D. Thompson

The night I got my first telescope, a little 60mm terrestrial spotting scope, I aimed it toward the Moon with great anticipation. After wiggling the mount around and carefully focusing, I was delighted to see more detail than I ever imagined could be seen. There, before my very eyes, was the reality of another world! I witnessed the stark illumination of the Moon's mountain ranges, plains, and craters. I watched, hour by hour, as the terminator passed across the lunar surface. To this ten-year-old boy it was as if the hottest science fiction had come to life!

I soon turned my little telescope on a multitude of stars, and slowly I began investigating those curious bright spots in the Milky Way. Much to my amazement I found strange, cometlike objects and star clusters all along the glowing band of light. When my father bought me the *Larousse Encyclopaedia of Astronomy*, it became apparent that all of my "discoveries" had already been discovered — many of them hundreds of years before.

Nevertheless, I was hooked on searching the depths of the universe to see what else I might find. Maybe if I were diligent or just lucky, perhaps I would find something no one else had ever seen. I developed an unquenchable thirst for seeing every object mentioned in the Larousse book and in Rice's *Celestial Handbook of the Heavens*. I naively attempted to see some really faint objects well beyond the limits of my rather primitive equipment. However, this led me to discover many valuable observational skills for the future.

Like many backyard astronomers I desperately searched for spiral arms in galaxies and for elusive detail in emission nebulae. I wondered about possible inhabitants as I gazed at the thousands of stars comprising bright globular clusters. In my late teens I traveled to the dark, country sky at my uncle's farm where, with my 4-inch Royal reflector, I was thrilled to see the shape of the Ringtail Galaxy, emission nebula NGC 604 in the galaxy M33, and M2 in Aquarius resolved into stars.

It was impossible for me to photograph these objects at the time, so I decided to write detailed descriptions of what the objects looked like. This proved especially useful with galaxies, my favorite objects. I paid particular attention to stars involved with a galaxy's light, cataloguing them so I would know if a supernova erupted in the galaxy. However, once I built up a large number of observations, I found words inadequate in portraying the subtle differences between objects.

During my first couple of working years I was a commercial artist. I used my artistic ability to sketch planets as realistically as I could. Then I began sketching deep-sky objects.

My passion for sketching increased because of two books. Hartung's *Astronomical Objects for Southern Telescopes* and *Burnham's Celestial Handbook* seemed wonderful when they came out, but later I wished they had contained well-done eyepiece drawings. Burnham's work contained plenty of photographs, but they don't show you *what you see* through a telescope.

At about this time I became intensely interested in discovering supernovae visually with my new 8-inch telescope. I also found that accurate drawings of galaxies might provide the means to do this project.

To make accurate supernova search charts, I had to accumulate plenty of galaxy sketches. It became apparent that I could draw the galaxies' subtle variations in luminosity better than photographs could show them. To make a cohesive set of these drawings, however, I had to compile an observation form that would permit a standardized format. This format should include as much information about the sketch as possible: telescope, magnification, field diameter, seeing, transparency, sky darkness, limiting magnitude, altitude of object, scale, and information about the object being sketched.

It seemed to me that too often sketches were published without all of this relevant information included. I wondered about the orientations of these drawings, whether the observer rushed the drawing because of cold or fatigue, how good the observer's eyesight was, the amount of light pollution at the observer's site, and other factors that significantly affect how drawings turn out. How could all of these parameters become standardized for my set of drawings and for those of others too?

I showed my first attempt at a standardized form to my friend Jeff Tolmie, also a deep-sky observer. Jeff offered to use his computer graphics facilities to draft several possible layouts for a standardized form. I would use the drafts over the next few months and continue making changes as they occurred to me. I sent the forms to other respected observers for comment, and in many cases their suggestions helped.

For observers, deep-sky sketching probably holds more fascination than scientific value. However, deep-sky sketching provides an invaluable training ground for critically studying what you see at the eyepiece. Making eyepiece drawings forces observers to scrutinize detail, proportions, locations, and brightness variations in a huge range of objects. There is no better or more interesting way to learn how to make the most of your eyesight, telescope, and eyepieces.

The observing form I adopted in the end is quite simple. It measures 8-1/4 inches by 11 inches and has punch holes near the left margin so drawings can be placed into notebooks. The drawing circle measures 6-1/4 inches in diameter; directional marks show north, south, east, and west. East and west appear on both sides of the drawing, and you simply cross out whichever set doesn't apply. Two boxes appear at top:

CONSTELLATION: CARINA

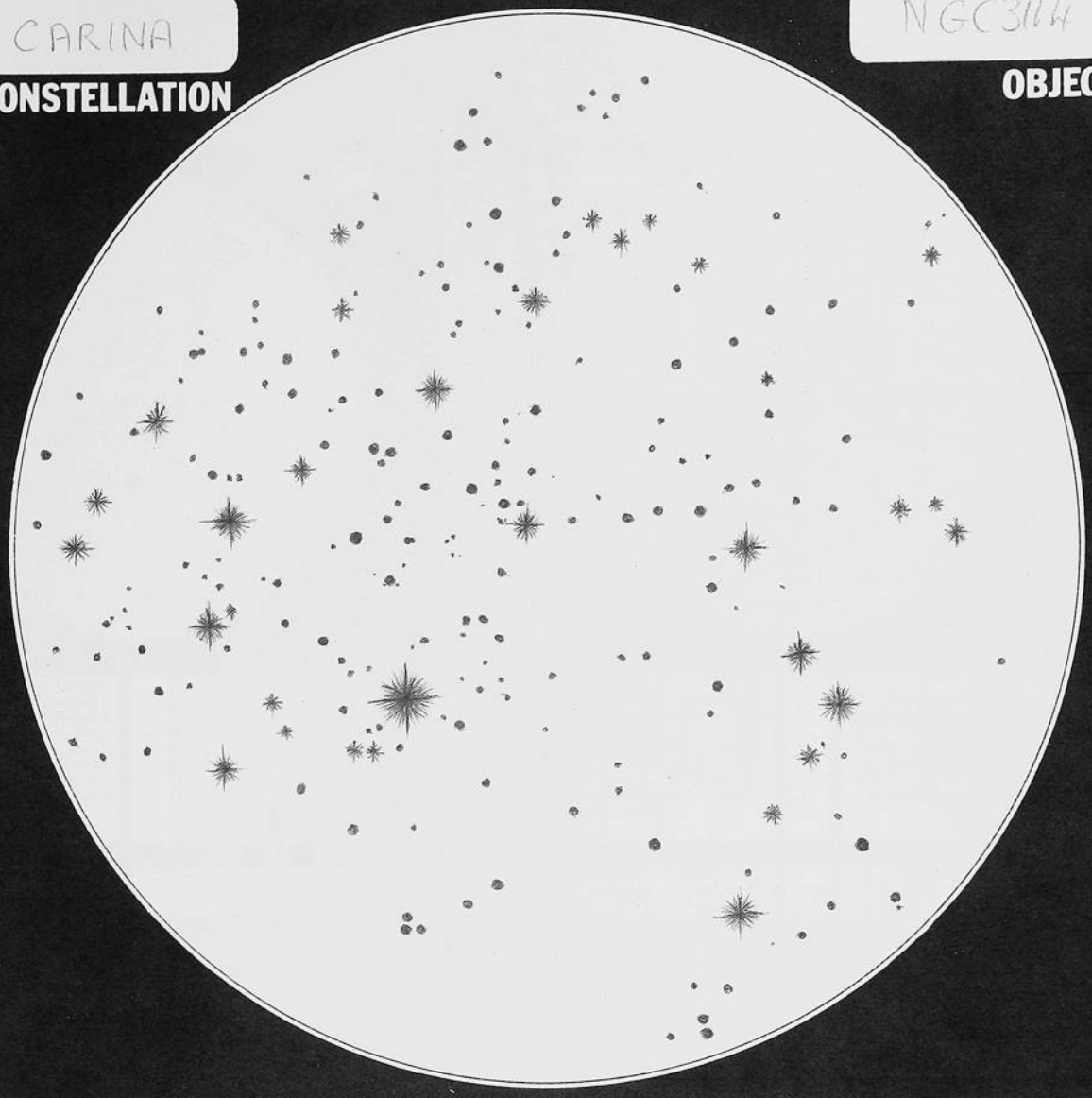
OBJECT: NGC3114

N

E

W

S



INSTRUMENT

Aperture	:	10cm
Focal Ratio	:	13
Telescope Type	:	Newt
Optical Quality	:	Low
Collimation	:	Excellent
Reflect/Transmiss	:	Good
Eyepiece	:	12mm TV no WA.
Magnification	:	123x
Field Diameter	:	1°
Filter Type	:	—

CONDITIONS

Seeing	:	3"
Transparency	:	3
Sky Darkness	:	3
Wind: Nil Lim. Mag	:	5.4
Temp: Dew	:	Nil.
Altitude of Object	:	60°
Altitude of Site	:	85m
Location of Site	:	Springwood Observatory

OBSERVER

Name	:	Gregg D. Thompson
Address	:	7 Strover Court, Springwood Qld, AUSTRALIA 4127.

Visual Acuity	: 4	Experience	: 1
Thres. Vision	:	Fatigue	: 1
Accuracy	: 2		

Designed by G. Thompson & J. Tolmie

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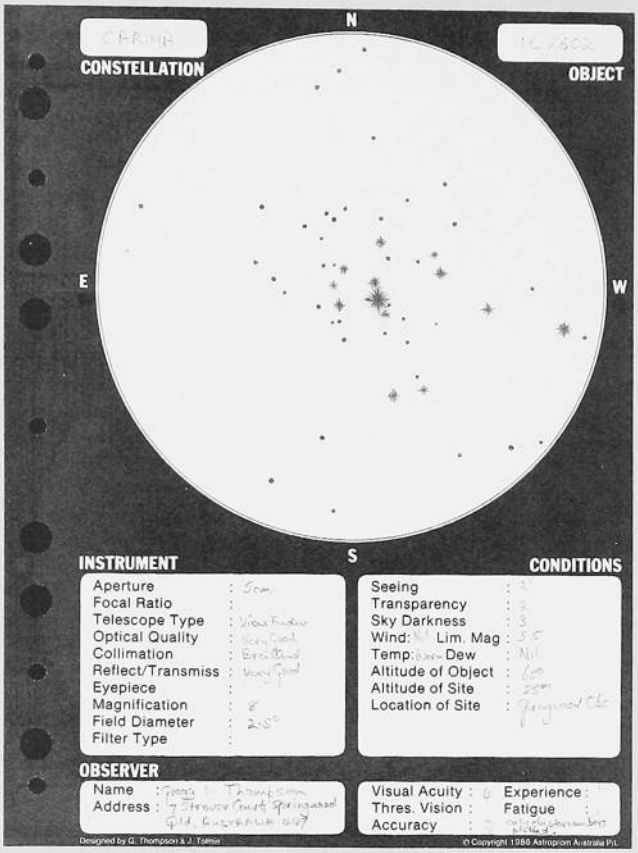
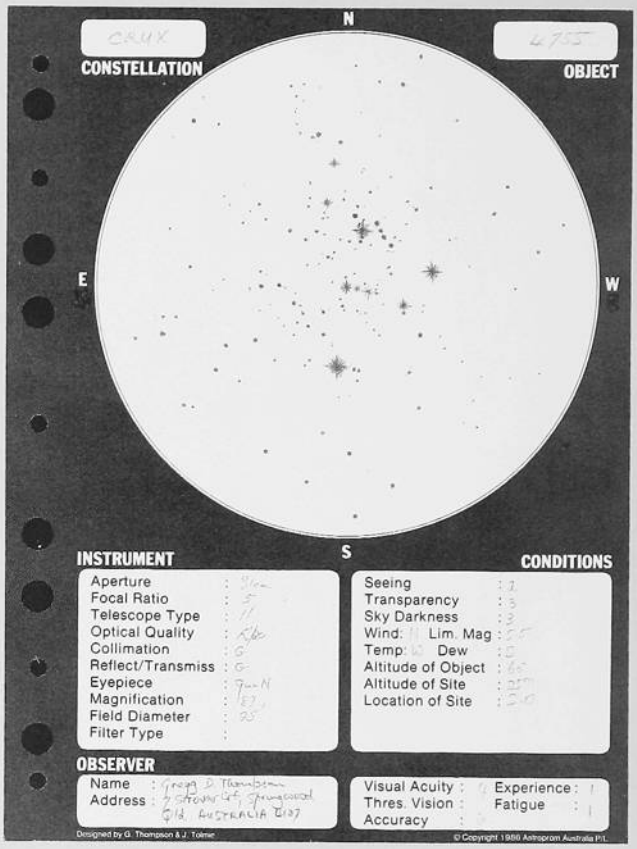




one for recording the constellation, the other for the object designation.

Instrumentation variables consume the lower left box on the form. Here you need to record the telescope's aperture, focal ratio, design, and optical quality. To measure optical quality in a telescope, I usually choose either 1/20, 1/10, 1/4, or 1 wave. A 1/20-wave mirror has an excellent figure that shows Saturn's rings crisply even at high magnification. A 1/10-wave mirror provides fairly good resolution at high powers. A 1/4-wave mirror is not particularly sharp at high powers. A 1-wave mirror is only reasonably sharp at its lowest magnification. Of course you'll have to get to know your mirror well before you categorize it, because factors like atmospheric turbulence and collimation also significantly affect image sharpness.

The next line in the instrument box is a collimation check. Make sure the alignment between primary and secondary mirrors is precise before you do any serious observing. Perfect collimation yields round diffraction rings in refractors and nearly round ones in reflectors. There is no flaring of star images to either side of focus, and the shadow of the secondary mirror appears centrally placed in the defocused image of a bright star.

Reflection/transmission refers to the reflectivity of a mirror's aluminized coating or the transmission of a lens. If your telescope has no problem in this area, leave it blank. If your mirror has poor reflection, make a note of it. If your scope has special overcoatings that enhance transmission or reflectivity, note them.

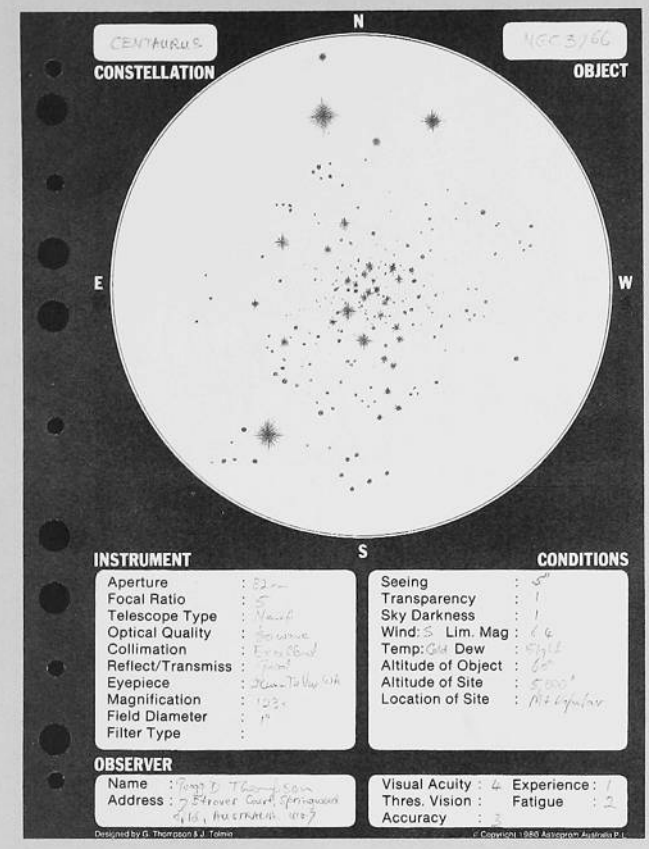
The following spaces allow you to record information on eyepiece used, magnification, field diameter, and whether or not you used any filter for the observation.

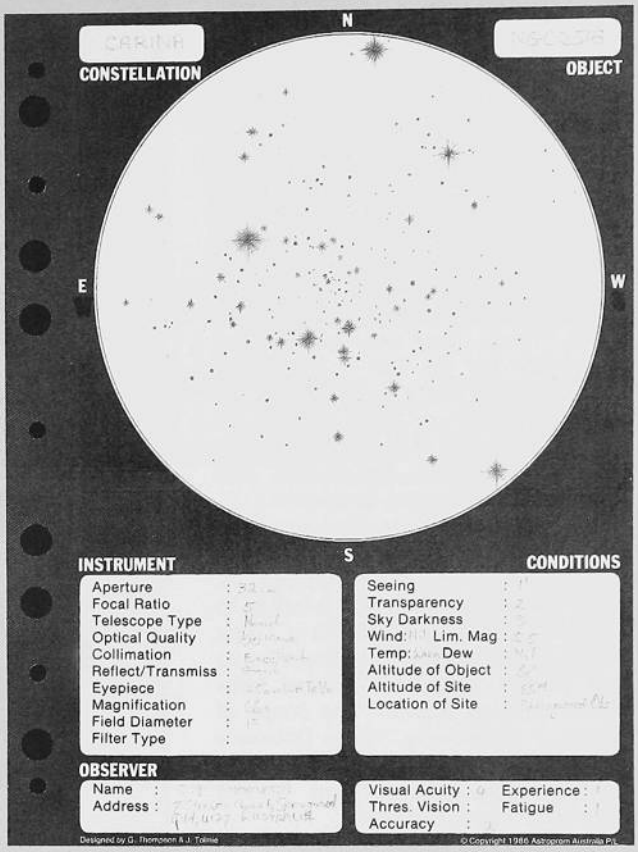
The right hand box is for information on sky conditions. There seem to be as many different scales for seeing and transparency and there are observers. Here is the seeing scale I use:

1. The atmosphere is so steady that even stars close to the horizon appear to twinkle only occasionally. Excellent high-magnification views may be obtained of the planets and close double stars.
2. The atmosphere is very steady with occasional disturbance of high-magnification images.
3. The steadiness is good but with regular air turbulence noticeable.
4. There is a general loss of fine detail at high magnification.
5. Twinkling stars are quite apparent, but the twinkling is not rapid. Images are unsharp at medium powers.
6. Fine detail is lost at medium power.
7. Star images show rapid twinkling. They appear disklike.
8. Fuzzy images are detectable at low power.
9. Stars appear blurry and appear to change brightness very quickly.
10. Atmosphere is boiling. There is a complete loss of detail.

Transparency is also a critical factor. Here is the scale I use for rating sky transparency:

1. This is used to indicate the clearest possible sky. If the atmosphere is





"perfectly transparent," then only a slight amount of haze is visible near the horizon. At a high-altitude site this condition usually results from relatively dry air moving in after rain or heavy dew.

2. Indicates a sky that is very clear but not perfectly transparent.
3. Haze is noticeable toward the horizon, but overhead the sky is perfectly transparent.
4. Very slight haze is noticeable overhead near bright objects.
5. Haze appears overhead, but faint stars are visible.
6. Obvious haze or thin clouds lie overhead.
7. The faintest stars typically visible from the site are not visible.
8. Smoke, haze, or fog limits visibility significantly and creates glare around bright objects.
9. At the zenith, absorption limits visibility by one magnitude.
10. At the zenith, absorption limits visibility by two magnitudes or more.

The next consideration is sky darkness. This refers to the level of artificial lighting, moonlight, or zodiacal light illuminating the sky. Even if the sky is perfectly clear, it may not be perfectly dark. Here is the scale I use for sky darkness:

1. There is a total absence of moonlight and artificial lighting in the sky. With good seeing and transparency, stars fainter than 6th magnitude are visible with the naked eye.
2. Very slight brightening of the sky (like that caused by zodiacal light).
3. Three-day-old Moon or slight light pollution, but 6th-magnitude stars are visible overhead.
4. Faintest portions of Milky Way barely visible.
5. Overhead appears fairly dark but sky is fairly bright around horizon.
6. Only the brightest portions of Milky Way are visible.
7. General illumination of the entire sky equal to seven-day-old Moon. Faintest stars visible are magnitude 5.5.
8. Sky is bright, similar to a three-quarter Moon.
9. Sky is very bright; faintest stars visible are magnitude 4.5.
10. Illumination equivalent to or greater than the Full Moon.

The following information is also recorded: wind direction and speed, limiting magnitude, temperature, dew, altitude of object, altitude of site, and site location.

At the bottom of the form, space is provided to record information about the observer, such as visual acuity, threshold vision, experience, and fatigue.

These forms have been a great help in establishing a set of uniform observations. When I think of the reference value these sketches will have many years from now, I can't help believing that indeed sketching astronomical objects is one of the greatest ways of observing the sky.

Gregg Thompson is an active deep-sky observer living in Australia. He operates Springwood Observatory, where he pursues sketching with a 12-inch telescope. His book containing supernova search charts will be published this autumn by Cambridge University Press.

Texas Star Party 1988

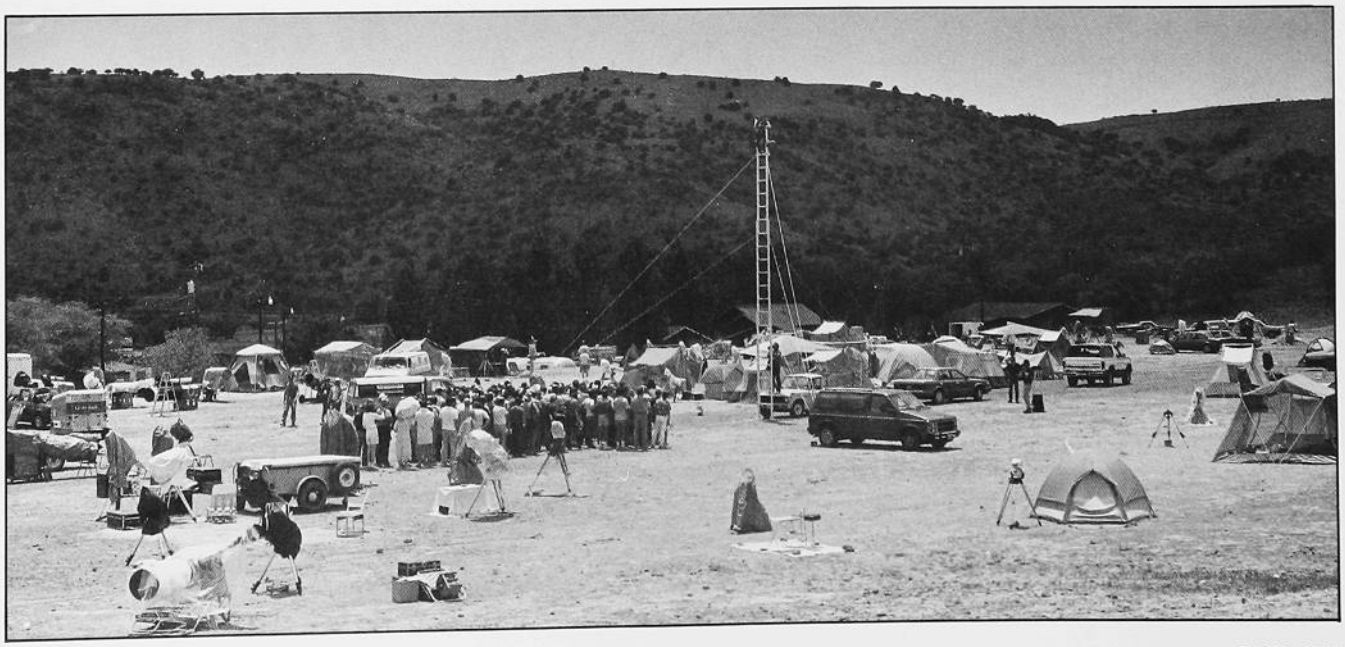
Last May 1988's Texas Star Party came off without a hitch, offered an extraordinary selection of guest speakers, clear skies (save for one or two nights), and some of the best darn chit-chat you ever heard west of the Mississippi.

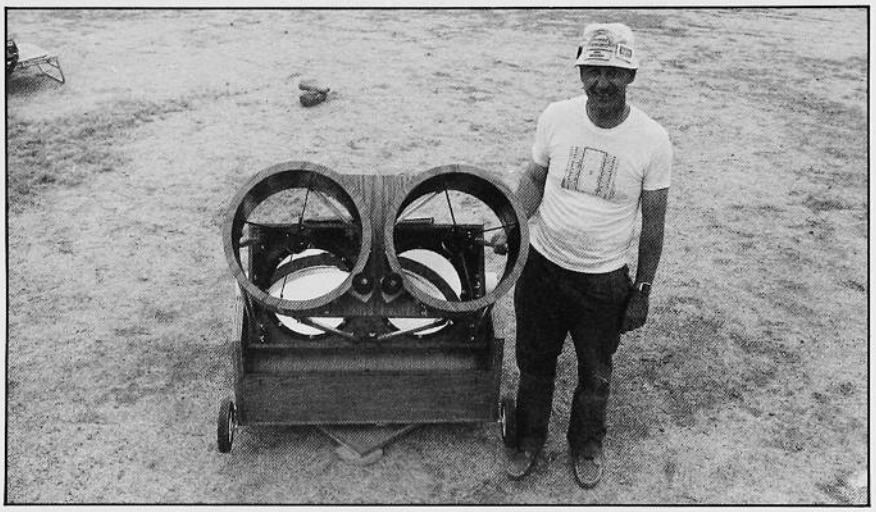
The event lasted from May 10 to 15 and took place, as usual, on the dusty but hospitable Prude Ranch in Fort Davis, Texas. This year saw record attendance for the TSP — some 625 people — and there were no run-ins with rattlesnakes or other hazards. (In fact, Ed Boutwell of Birmingham, Alabama, well known for certain past scrapes, even escaped unscathed.)

Amateur talks during the convention ranged from an astrophotography seminar by Klaus Brasch, Robert Reeves, Mike Mayerchek, and Jack Marling to "What Your Club Needs Is a Great 25-Cent Planisphere" by Robert Loper and Danny Zumbrun. Invited talks included Brian Skiff's "The Scope of Amateur Astronomy," John Dobson's "Bigger Eyes on a Vast Universe," and Jay Gallagher's magnificent "Seven Mysteries about Galaxies."

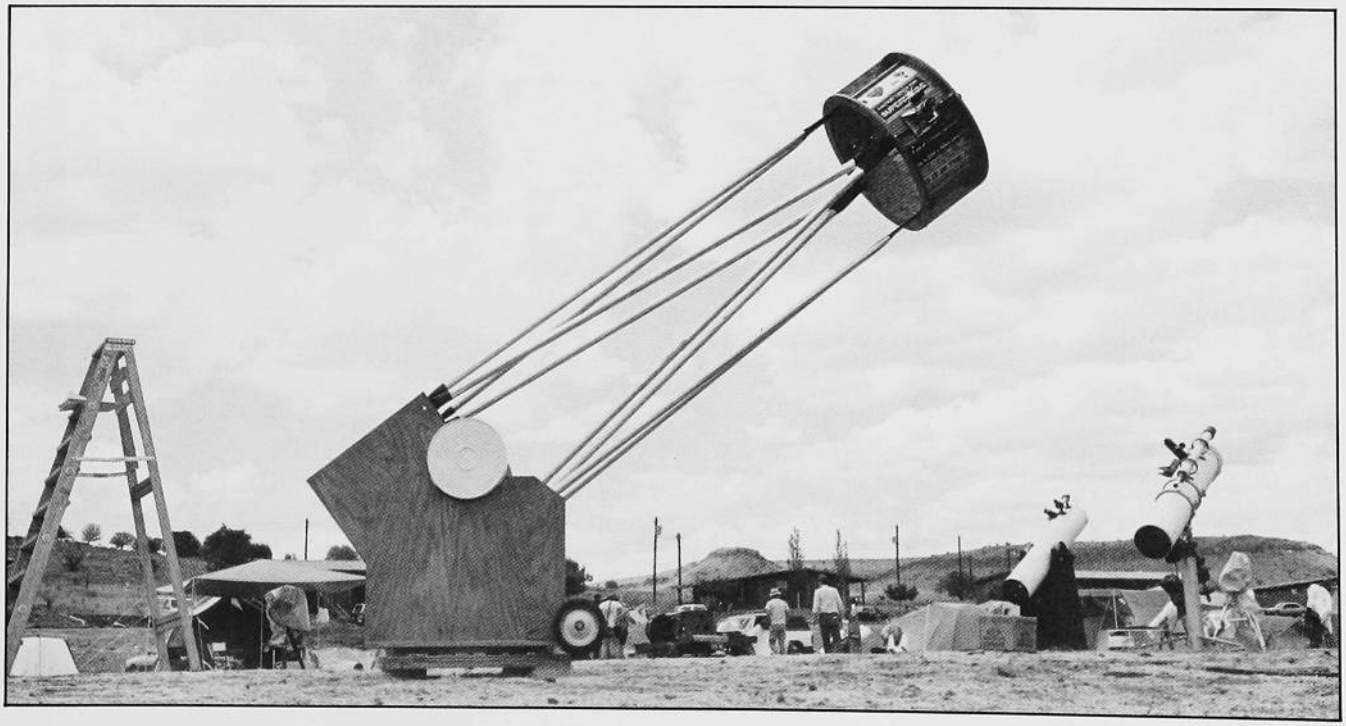
The observing was fantastic as usual, once again proving that it's well worth spending your spring savings to stay for a week on a dusty ranch in the middle of nowhere. Views of Omega Centauri and many other deep-sky objects stunned and thrilled those who saw them through a big scope for the first time. — *David J. Eicher*

Above: Robert Reeves sways in the wind on a 30-foot ladder as he prepares for the group photo. "I never knew astronomy could be so dangerous," he said after climbing down. Below: Astronomy, Texas-style. Over six hundred amateur astronomers from all across the country and abroad visited Fort Davis for the 1988 Texas Star Party. All photos in this article by David J. Eicher.





Robert Suding of Conifer, Colorado, brought his impressive "Star Cannon II." Modeled after Lee Cain's binocular Dobsonian, Suding finely crafted a rotating eyepiece holder (above left) and a superb tube made from red oak and aluminum struts. And who says nobody likes astronomical bumper stickers anymore? Suding's "Star Cannon I" (below), an 18-inch f/6 reflector, towered over other telescopes on the upper field. Built using similar materials, the first star cannon moves smoothly and is a joy to use at night.



My First Texas Star Party

The drive from Midland Airport to the Prude Ranch in Fort Davis proved to be somewhat tedious: nothing but flat, open fields; oil wells; and thousands of roaming cattle. As we approached the Davis Mountains, Bob Ruhoy and I were startled at the swift change of scenery. The flat lands vanished and we began to climb the mountains.

It was Thursday, May 12, 1988. Although the Texas Star Party had begun earlier in the week, we were only going for a long weekend. Why would two New Jersey residents travel all that way for a long weekend? We wanted a dark sky wherever we had to go to find it.

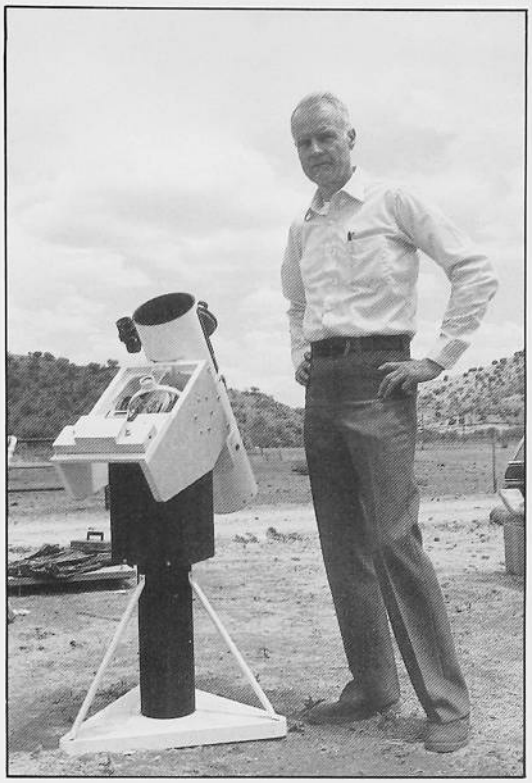
We finally reached the ranch, registered, and found a room to sleep in. I came armed with a Tuthill two-camera drive and a pair of 11x80 binoculars. I was prepared to feed both cameras over 140 frames of hypered 3200 Konica film. I would observe by roaming from scope to scope, peeking into telescopes brought by others.

As darkness fell that Thursday evening, I set up the cameras and readied myself for the best possible sky. Everyone seemed nervous; the previous night had been cloudy, and everyone desperately hoped tonight would be different. It was. Comet Liller was an easy naked-eye object and I was amazed to see the North America Nebula as a bright naked-eye object as well. We observed late into the night, talking, laughing, gasping, and sharing our thoughts on the cosmos.

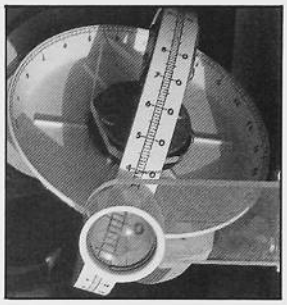
Besides the excellent observing, we enjoyed many good talks by featured speakers. The ranch offered horseback riding, a heated pool, and hiking trails for those who want nonastronomical daytime activities. I very much enjoyed meeting a wide range of well-known personalities including Jack Marling of Lumicon, Biff Bigbie of Astro-Tech, Dan Gordon of Spectra Astro-Associates, Tom Lorenzin of 1000+, and Brian Skiff of Lowell Observatory.

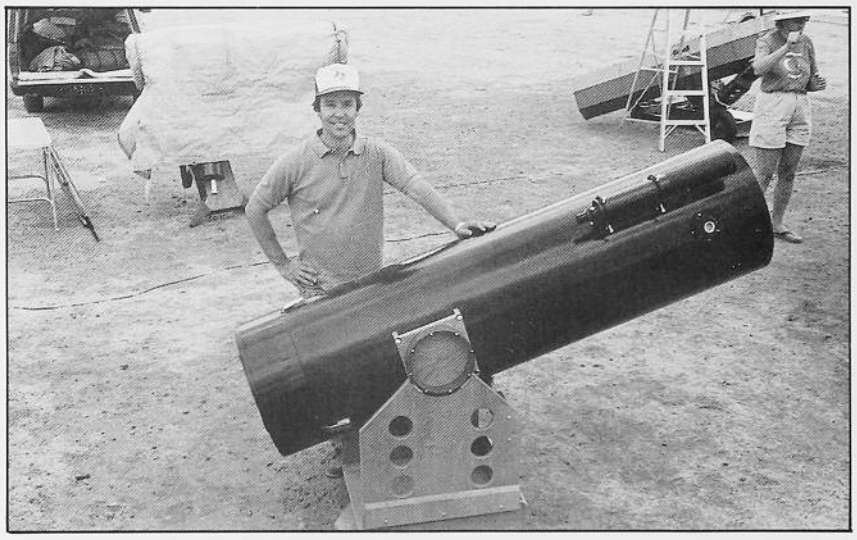
I saw some impressive sights using 17.5-inch and 20-inch telescopes, including the Veil Nebula, Centaurus A, Omega Centauri, and the North America Nebula. I also saw Mercury for the first time.

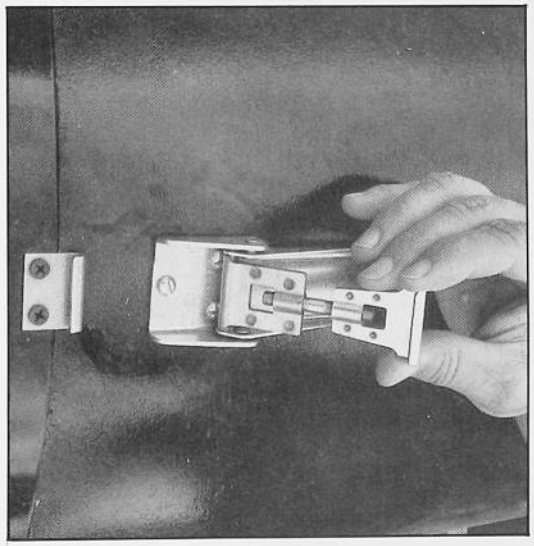
We rose early on Sunday and started home. The ranch was empty when we started back toward Midland. Attending the TSP was an experience I'm going to remember for a long time to come. When my memory starts to fade, I'll just have to come back for another few days of therapy! — *Benjamin H. Funk, Jr.*



Walter Farrar of Mountain Park, New Mexico, proudly displays his 6-inch RFT with built-in armillary sphere setting circles. After setting the inner circle to current sidereal time, Farrar dials in right ascension and declination on the outer circle to find objects.

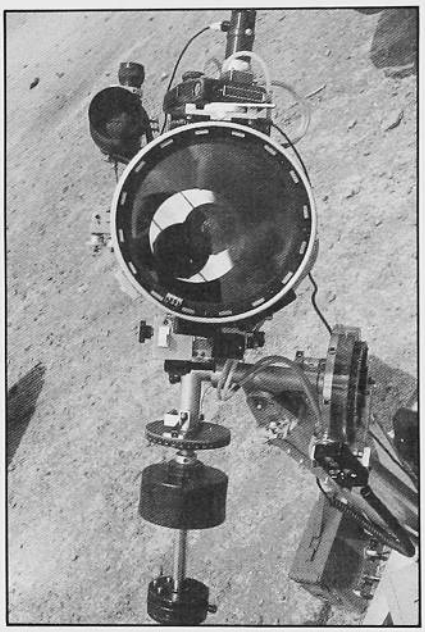


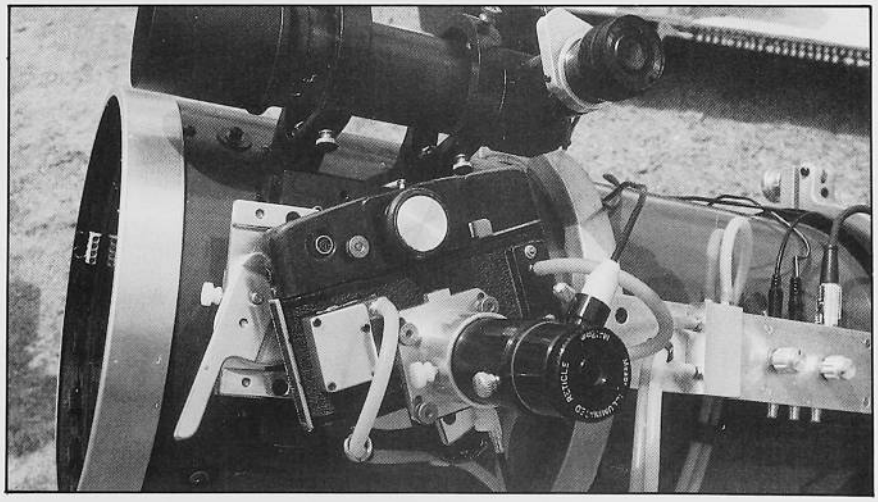




St. Petersburg's David Knowlton refinished his 17.5-inch f/4.5 Dobsonian after his first mount was "accidentally smashed." His beautiful telescope is crafted from bendable-birch plywood and features niceties like a snap-on mirror compartment.

"The ultimate astrographic rig" would probably characterize Bill Harris' superb job of machining. This 8-inch f/4 Wright-Newtonian has a built-in vacuum to keep film flat and dry, a rotatable camera and a built-in off-axis guider, and anti-dew resistors (below and below left). Many of Harris' photos made with this scope will appear in future issues.





Paula Berland of Conroe, Texas, built this simple, elegant, 13.1-inch f/4.5 Dobsonian with a low-profile focuser (right). A member of the Houston club, she uses it to hunt down faint galaxies and nebulae.

The Illusion of Maffei 1

by Don Pearce

For several months last year I carried a copy of an *Atlas Stellarum* chart showing the strange galaxy Maffei 1. Before this I had never heard anyone mention the galaxy except as a serious challenge to large telescope owners. No one in our group, the Houston Astronomical Society, had seen the mysterious object. In fact, the only knowledge I had of Maffei 1 was a reference in the Spring 1987 *Deep Sky*, where someone mentioned seeing this faint object with a 10-inch telescope. I didn't know it, but I was about to become intimately familiar with Maffei 1.

On the night of November 20, 1987, I went along with some friends to observe at a site near Columbus, Texas, about eighty-five miles west of Houston. After some time Larry Mitchell asked me to find Maffei 1 in the 17.5-inch telescope I had brought along. I pulled out my copy of the *Stellarum* chart and after a few minutes I located the correct field. The galaxy immediately popped into view.

I switched to a higher-power eyepiece (154x), and after examining the field for a few seconds, I saw Maffei 1 as an elongated object almost resembling an edge-on spiral galaxy. Larry and another observer confirmed seeing this shape. However, several other experienced observers either saw nothing or saw the galaxy without any elongation. To these observers, Maffei 1's core was plainly visible and framed by a "trapezium" of stars, but the elongated halo of material around the core seemed elusive.

The question of Maffei 1's elongation was further complicated because *Sky Catalogue 2000.0* lists Maffei 1 as an E3 elliptical galaxy. In my mind that conjured up an oval shape, not the elongated shape the three of us thought we were seeing. That bothered me enough to check the *Stellarum* chart, and I found the galaxy's position and the trapezium with a magnifying glass. I was now sure we were looking at Maffei 1, but what about the galaxy's elongated shape?

Larry and I decided to research this question, but as we checked into the matter, things only became murkier. Oddly enough, most of the texts we have found contain little or no mention of Maffei 1 and no photographs. In fact, *Deep Sky* turned out to be the best source of observing information on the galaxy, and in going through some back issues, I found several observing descriptions and drawings.

Apparently Maffei 1 was at one time listed as having a surface brightness of 19, which places it well beyond the reach of backyard telescopes. The observing literature reflected this assertion. Then amateur observers began reporting observations of this galaxy. In *Deep Sky #9* there is a drawing of Maffei 1 made by Chris Schur that seems to include only the central core of the galaxy without any extensions.

Solid evidence for the visibility of Maffei 1 seemed hard to track down. I checked the Palomar *Sky Survey* charts and saw that Maffei 1 is virtually invisible in blue but prominent in red light. There is a photograph of the galaxy in Vehrenberg's *Atlas of Deep Sky Splendors* (it's visible in the plate on page 41) that somewhat resembles our observations, but surprisingly most of the photos I've seen of the galaxy don't resemble one another.

Eventually we located a book written by the discoverer of Maffei 1, Paolo Maffei. *Beyond the Moon* contains a rather poor reproduction of a photo made with the 5-meter Hale telescope that shows Maffei 1's central core. The section devoted to Maffei 1 offers compelling evidence that Maffei 1 is an elliptical galaxy, because it doesn't emit radio waves among other reasons. Case closed? No.

I was so sure of our observations showing Maffei 1 as an elongated object that I decided to return to the Columbus observing site and sketch my impression of the galaxy. Again, the faint extensions were visible, but the transparency wasn't quite as good that night and the extensions didn't appear as prominent.

I was now stuck with finding an explanation for this. There were several possible explanations. First, the faint extensions are illusionary, caused by patterns of stars too dim to be resolved by my telescope. Second, the visible stars that somewhat outline the shape of the extensions are surrounded by "dew glow" (moisture in the atmosphere) that creates an illusion of "extensions" of the galaxy. Or, the explanation could be a combination of dim stars and dew glow.

Two less likely explanations also came to mind. The illusion could be produced by H II regions in our Galaxy. Or we could be seeing portions of Maffei 1 that — for reasons I can't account for — are visible at wavelengths the human eye is most sensitive to but that cameras don't record.

At first I wanted to believe this last reason, but I gradually came to think that the first four reasons might explain the illusion. Have other *Deep Sky* readers observed this faint extension of Maffei 1, and if so, can anyone shed any light on it?

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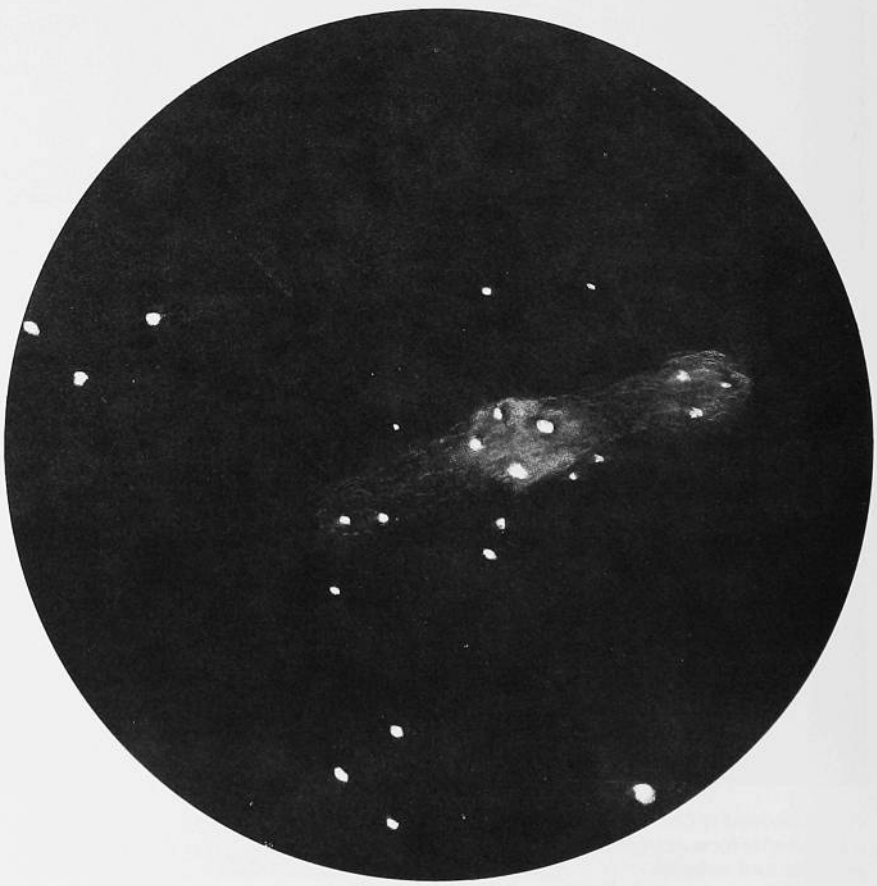
Maffei 1 sketched by Don Pearce (below) and photographed by Martin C. Germano (right). Pearce used a 17.5-inch f/4.5 reflector at 154x, which yielded a 30′ field of view. Germano used an 8-inch f/10 SCT, 103a-F film, and a 40-minute exposure.



Autumn's Galaxy Groups

by David Higgins

As the warm nights of summer give way to the cool, crisp nights of autumn, the Milky Way slips into the west. With this change of seasons also comes a change in the type of objects we can observe. Gone are the huge gas clouds of the Milky Way and the swarms of globular and open clusters. In their wake rise the constellations that harbor some of the most observed and talked about objects in the sky — galaxies.

Galaxies were not always thought of as systems like our own Milky Way. Prior to 1924, they were generally thought to be clouds of gas and dust shining from the light of hot stars embedded within. But some visionaries thought of nebulae as large systems of stars. As early as 1755 Immanuel Kant believed that these "nebulous appearing luminous objects" were island universes. The discovery and cataloguing of nebulae was in full swing by the close of the eighteenth century.

The Realization of Galaxies

One of the most significant contributions to our understanding of these objects was provided by William Herschel. Herschel systematically surveyed the northern sky, and later his son John extended the survey into the Southern Hemisphere. Herschel's observations were made with the world's first large reflecting telescopes, designed and built by William.

Herschel believed that nebulae were galaxies like our own Milky Way. However, he found that many nebulae could be resolved into individual stars, some of which were surrounded by hazy glows. It was so hard to reconcile the appearance of such an object with that of a remote stellar system that by 1791 Herschel had abandoned his island universe hypothesis.

Although the weight of astronomical opinion rejected the island universe hypothesis, the concept of the possibility of other galaxies never quite disappeared from astronomical thought. By 1908 the 60-inch telescope on Mount Wilson had been completed; within another decade the 100-inch telescope was finished. With these giant telescopes, Edwin Hubble resolved the controversy by discovering variable stars in some "spiral nebulae." By 1924 Hubble had analyzed the light curves of variables he had discovered in M31, M33, and NGC 6822 and found that they were Cepheids. Although Cepheids are intrinsically bright supergiant stars, the ones Hubble found were very faint. Those stars, therefore, and the "nebulae" in which they were found, were located at extremely large distances. Hubble established that spiral nebulae were galaxies.

Hubble spent years studying galaxies. He classified six hundred galaxies and found they could be divided into four major types: ellipticals, spirals, barred spirals, and irregulars. An elliptical galaxy looks like a partly flattened, luminous sphere. Some of these galaxies are nearly perfect spheres, others are moderately flattened spheres, and still others are extremely flat objects like pancakes. Hubble labeled all elliptical galaxies according to their degree of flattening. He designated the spherical galaxies E0, the slightly flattened ones E1, and so on down to E7, for the flattest, most elliptcal ones. Elliptical galaxies constituted 20 percent of Hubble's sample. Their main property, apart from their shape, is that they contain only old stars. Elliptical galaxies were under represented in Hubble's count and probably constitute the majority of all galaxies.

Hubble classified 50 percent of the galaxies he observed as spirals. They were his largest single class of galaxies. Spiral galaxies have the shape of a flattened disk of matter, with a small, spherical nucleus bulging out of the center. The stars in a spiral galaxy are concentrated in the central nucleus and in the spiral arms that radiate out from the center. These arms give the spiral galaxy its name. Hubble classified spiral galaxies into three basic types — Sa, Sb, and Sc — according to the degree of openness of the siral arms. The Sa type has a number of spiral arms very close together and almost overlapping. In Sb spirals the arms are well defined although still relatively close. In Sc type spirals there are only a few arms, each clearly separated from the others.

About 30 percent of all spiral galaxies were classified by Hubble as barred spirals. They resemble Sc spirals, with two arms radiating outward. However, instead of coming out of a small central nucleus, the arms project from the ends of a bar-shaped concentration of matter. This bar gives the galaxy its name. Hubble classified barred spirals into three types — SBa, SBb, and SBc — depending on the degree of openness of the spiral arms, following the same scheme for classifying ordinary spirals. Barred spirals are similar to ordinary spirals in every respect, such as the types of stars the contain, their mass and luminosity, their haloes, and their distribution of gas and dust.

A small fraction of all galaxies do not fit into one of these categories. They do not have a clearly defined geometric form. These galaxies are called irregulars. Most of them are relatively small, with one thousandth of the mass of a typical spiral or elliptical galaxy. Irregular galaxies often contain many bright, young stars and few old stars. Frequently an irregular galaxy is attached to a spiral galaxy, held captive by the gravitational force of the massive spiral. The Magellanic Clouds, satellites bound to our Galaxy, are examples of captive irregular galaxies.

Just as stars tend to group together in clusters, galaxies tend to be associated in groups or clusters. These clusters range from several dozen members to thousands. (The Milky Way itself is part of a small group of galaxies called the Local Group.) In 1957 George O. Abell catalogued 2,712 galaxy clusters from the *Palomar Observatory Sky Survey*. Fritz Zwicky eventually completed a survey that increased the number of catalogued clusters of galaxies to about 10,000.

These days Abell's catalogue of galaxy clusters is difficult to obtain. Most of the clusters listed in it are not within the range of backyard telescopes. The Webb Society's book *Clusters of Galaxies* contains a number of examples within reach of amateur telescopes. The Webb Society defines a group of galaxies as a poor cluster with at least four galaxies brighter than 15th magnitude. The cluster also must include at least one NGC or IC object in a circular area of sky 1/2 degree in diameter.

With the completion of *Uranometria 2000.0*, backyard observers have a tremendous source of deep-sky objects. All of the NGC objects are plotted. This makes it easy to see that some areas of the sky are crowded with galaxies. Some of the Abell clusters are plotted on this atlas.

Observing Galaxy Groups

I observe with a 24-inch f/4 Newtonian and a 13mm Nagler eyepiece, which provides a magnification of 187x and a field of view of 26'. This is enough magnification to discern faint members of galaxy groups and a wide enough field of view to fit most groups into a single eyepiece field. The following descriptions of groups of galaxies include groups listed in the Webb Society book as well as a number of other groups. If you have *Uranometria 2000.0*, notice that some constellations have a number of groups that contain anywhere from two or three galaxies to a dozen or more.

Most galaxy groups contain several members with magnitudes ranging from 15.5 to 17. Through the 24-inch scope, magnitude 15.5 is just about the limit on a night of average seeing. But don't let these magnitudes stop you from trying to observe galaxy groups. Most groups contain a few galaxies visible through smaller telescopes and provide a fascinating way to spend clear, autumn evenings.

The **NGC 128** group is located in Pisces at right ascension 0h29.3m, declination +2°52'. (Remember that the coordinates for a group are given the

brightest galaxy's position.) NGC 128 glows faintly at magnitude 12.7. It is elongated, has a bright middle, and the haze that surrounds it fades gradually outward.

NGC 130, a 15th magnitude magnitude object, lies just east of NGC 128. It is a small oval haze with no apparent nucleus. Averted vision was required to see it.

NGC 125 lies west of NGC 128. This 14th-magnitude galaxy presents a visible nucleus surrounded by oval haze. Two field stars lie just northwest of the galaxy.

NGC 127 can be found just north of a point midway between NGC 128 and NGC 125. At 15th magnitude, NGC 127 is little more than an oval haze. It is visible only with averted vision. A solitary field star lies to the south.

Just south of a point midway between NGC 128 and NGC 125 lie two field stars. Southwest of the southernmost field star lies **NGC 126**. This galaxy glows at magnitude 15.5.

The **NGC 192** group in Cetus is located at right ascension 0h39.3m, declination +0°51′. NGC 192 is large and bright with a stellar core. It is elongated and glows at 14th magnitude.

NGC 196 lies north of NGC 192. It is a small, oval haze with a slightly brighter nucleus.

NGC 197 lies just north of NGC 196. Averted vision was required to see this faint, oval haze. It shines at 15th magnitude.

NGC 201 is the largest of the group but also faint. This galaxy is spread out and shows only a hint of core. Averted vision was required to see it. A faint star lies to the east of this 14.7-magnitude galaxy.

The **NGC 529** group is listed in the Webb Society's book on galaxy clusters and is located in Andromeda at right ascension 01h24.1m, declination +36′. NGC 529 shines at magnitude 13 but is small and oval. The middle is a little brighter and gradually fades outward.

NGC 531 is a 15th-magnitude haze.

NGC 536 is elongated with a bright middle. A faint glow surrounds the nucleus. It is a magnitude-13.2 galaxy.

NGC 542 is the dimmest of the group, glowing at magnitude 15.5. It is a small, faint, oval haze visible only with averted vision.

The **NGC 750** group is the largest group I observed, but it is also the faintest. This group lies in Triangulum at right ascension 01h57.5m, declination +33°13′. At magnitude 13.2, NGC 750 is the brightest of the group. This galaxy has a bright center and also shows what looks appears to be a companion. This is **NGC 751**, a 13.5-magnitude glow with no central condensation.

NGC 761 lies northeast of NGC 750 and shines at magnitude 14.5. Its dim light requires averted vision to spot.

Autumn Galaxy Groups

Object	R.A. (2000)	Dec.	Mag.	Size
NGC 128	0h29.25m	+2°51.9′	12.6	3.4′x1.0′
NGC 130			15.0	
NGC 125	0h28.8m	+2°50′	13.2	2.0′x1.8′
NGC 127	0h29.2m	+2°52.4′	15.0	1.0′x0.8′
NGC 126	0h29.1m	+2°49′	15.5	1.4′x0.8′
NGC 192	0h39.3m	+0°51′	13.9	2.3′x1.2′
NGC 196			14.0	
NGC 197			15.0	
NGC 201	0h39.7m	+0°51′	14.7	2.2′x1.9′
NGC 529	1h24.1m	+34°36′	13.0	
NGC 531			15.0	
NGC 536	1h26.4m	+34°43′	13.2	3.7′x1.9′
NGC 542			15.5	
NGC 750	1h57.5m	+33°13′	13.2	1.6′x1.3′
NGC 761	1h57.8m	+33°23′	14.5	1.6′x0.6′
NGC 739			15.0	
NGC 736	1h56.7m	+33°03′	13.2	2.0′x1.9′
NGC 738			15.5	
NGC 740	1h56.9m	+33°01′	14.9	1.7′x0.5′
NGC 733				
NGC 978	2h33.3m	+32°45′	13.3	
NGC 978B			15.0	
NGC 969			13.5	
NGC 974			14.0	
NGC 970			15.5	
NGC 7782	23h53.9m	+7°58′	13.1	2.4′x1.4′
NGC 7781			15.0	
NGC 7779	23h53.4m	+7°52′	13.6	1.6′x1.3′
NGC 7778			14.0	
NGC 7780	23h53.6m	+8°07′	14.8	1.2′x0.7′

NGC 739 lies northwest of NGC 750. This 15th-magnitude galaxy is small and faint, appearing almost stellar at low powers.

At magnitude 13.2, **NGC 736** is the next brightest galaxy. This object has a bright center; a field star lies to the east. It nearly forms a double galaxy with NGC 738.

NGC 738 lies just east of NGC 736 and faintly glows at magnitude 15.5. This galaxy almost touches NGC 736.

NGC 740 is a 14.9-magnitude oval haze south of NGC 736.

NGC 733 lies northwest of NGC 736. It is faint; averted vision is required to see it. NGC 733 has a tendency to "fade in and out."

The **NGC 978** group is also listed in the Webb Society book. This group lies in Triangulum at right ascension 02h33.3m, declination +32°45′.

NGC 978 is also listed as **NGC 987a**. It has a companion galaxy listed as **NGC 987b**. NGC 978 shines at magnitude 13.3 and is oval with a bright middle.

NGC 978b lies just south of NGC 978a and shines at magnitude 15. It is small and faint. As a matter of fact the light from NGC 978a interferes in seeing NGC 978b. There is a field star to the south.

NGC 969 is listed at magnitude 13.5. It is fairly small but quite bright.

NGC 974 lies east of NGC 969. Its round haze is large but faint. The galaxy is flanked by two field stars, one to the southwest and one to the northeast. Its listed at magnitude 14.

NGC 970 is faint and small. Its magnitude is 15.5.

The **NGC 7782** group is a compact group of galaxies in Pisces. It is located at right ascension 23h53.9m, declination +7°58′. At 13th magnitude, NGC 7782 is the brightest of the group. This galaxy is very large, bright, and noticeably elongated. The nucleus is much brighter than the surrounding haze.

NGC 7781 lies south of NGC 7782. It is a round, compact, 15th-magnitude galaxy. It shows no sign of a nucleus.

NGC 7779 is a 13.6 magnitude object west of NGC 7781. Its bright, oval haze shows a hint of nucleus. The haze that surrounds NGC 7779 fades gradually outward.

NGC 7778 lies west of NGC 7779. Its small, round shape is dim at 14th magnitude. I did not notice any nucleus.

NGC 7780 shows some hint of elongation. Its 14.8-magnitude haze is uniformly illuminated.

With the ever increasing size of telescope mirrors, projects involving faint galaxies are a fascinating way to spend the cool, clear nights of autumn. Before the cold grip of winter's cloudy skies puts a damper on observing, get out and enjoy what the universe has to offer.

Blood on the Sky

by T. C. Hoffelder

Red stars don't get an even break. If you're like most observers, you've probably never viewed R Leporis, a ruddy beacon discovered by J. R. Hind in 1845 and also known as Hind's Crimson Star. One of the reddest bright stars in the sky, R Leporis lives up to the description, "a blood drop on the background of the sky." Along with S Cephei and Y Canum Venaticorum, R Leporis steals all the publicity for class N stars in the small amount of print devoted to this type of star. But there are many more of these beautiful objects scattered across the sky.

Class N stars are giants with surface temperatures around 2500 kelvins, the coolest of all stars. The spectra of these giants show strong emission in carbon molecules, one of which — triatomic carbon — strongly absorbs blue wavelengths of light. This combination of cool temperature and blue absorption results in the lovely ruddy hues we see in these carbon stars.

Most carbon stars are somewhat variable in light output and are predominantly semiregulars with variations of a magnitude or two. Some, however, are long-period variables with ranges of more than five magnitudes. R Leporis and S Cephei fit into this class. Because they are normally most colorful at minimum, these stars don't appear too striking when they're near maximum light.

All the carbon stars are too distant to allow parallax distance determinations to be made, but their maximum absolute magnitude is thought to be about −2. If true, this places R Leporis at a distance of 500 parsecs, S Cephei at 600 parsecs, and Y Canum Venaticorum at 150 parsecs.

The sixty-five carbon stars presented in the accompanying table are the brightest listed in *Burnham's Celestial Handbook* north of −50° declination. Included with other vital information on the stars are right angle sweep stars and directions. These allow you to find an easily locatable star and sweep in two axes to find the field of the carbon star.

Carbon stars deserve your attention for several reasons. Run-of-the-mill variables are interesting to watch, but carbon stars also vary in color intensity. They are easier to locate than many variables because of their strong colors. If you've never viewed one of these objects, your first sighting will leave you wondering how any star could shine so intensely red. If you have viewed a few carbon stars, the list should give you many more examples to observe on nights throughout the year.

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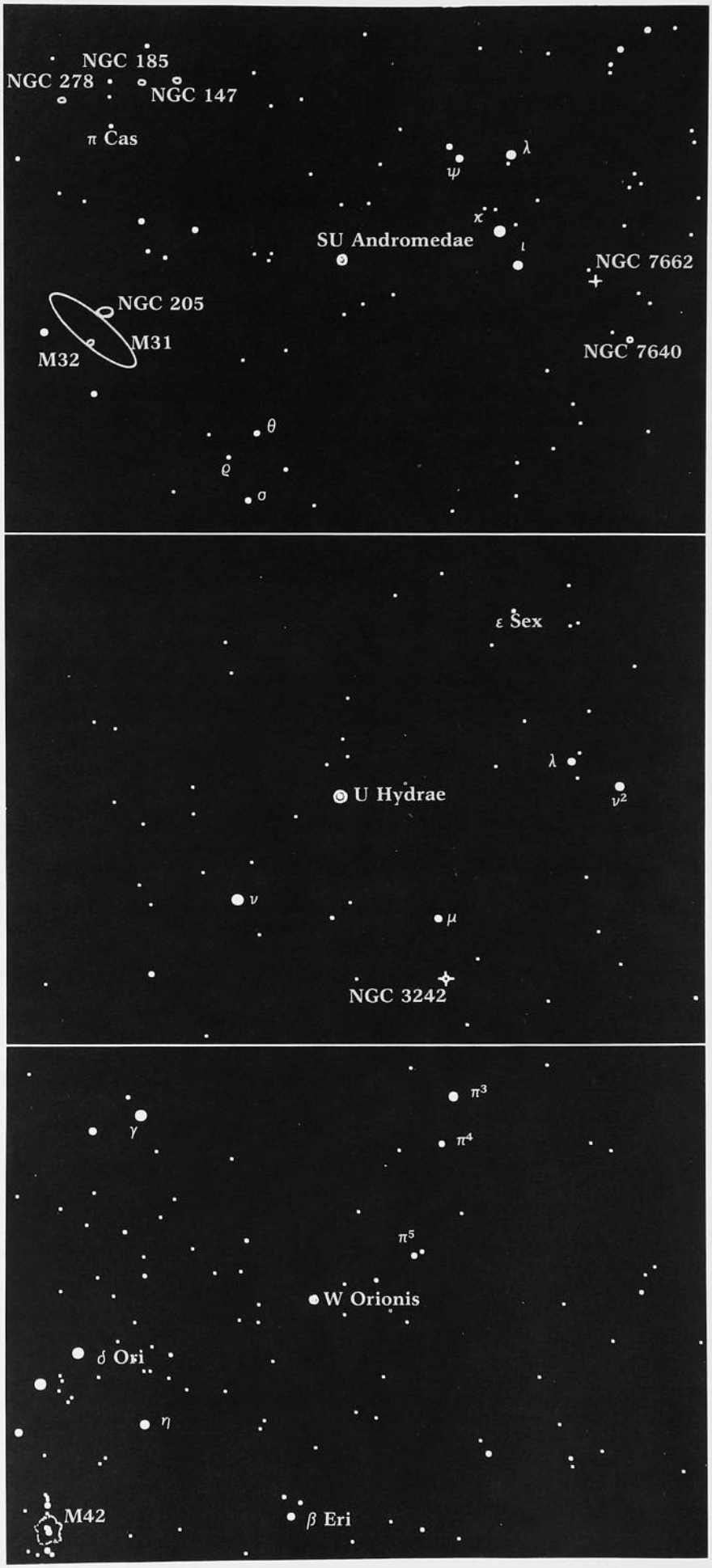
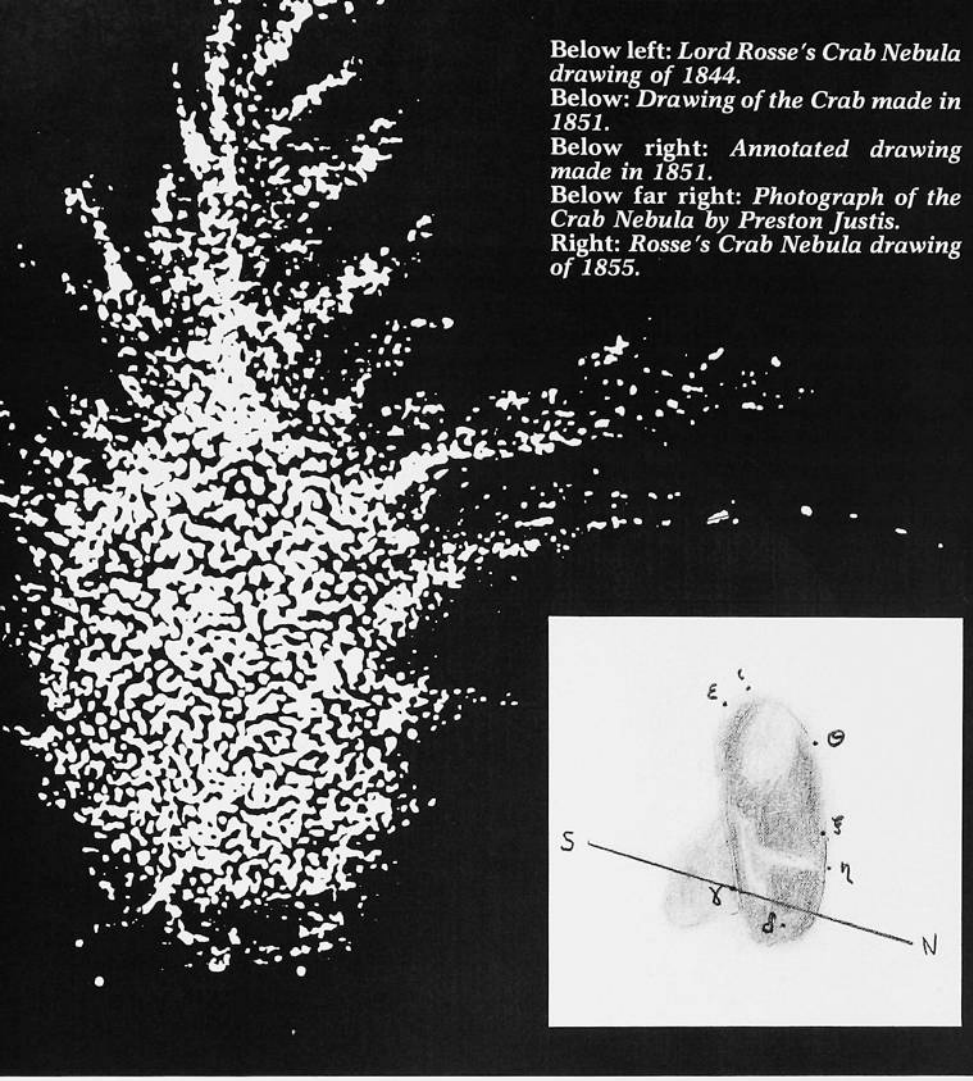
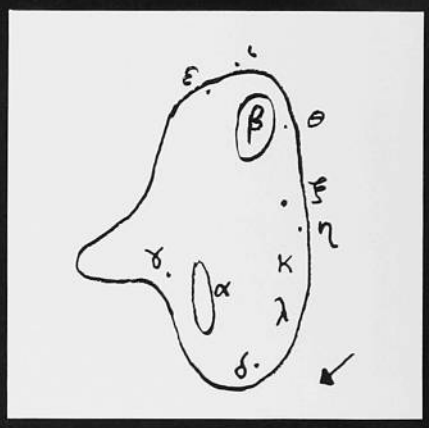


The Sky's Best Red Stars

#	Object	R.A. (1950)	Dec.	Magnitude Max.	Min.	Period	Class	Sweep Star	Dec. Sweep	R.A. Sweep
1	SU And	00h02.0m	+43°16′	7.6	8.5	Irr	N	θ And	4.9°N	2.4°W
2	VX And	00h17.2m	+44°26′	8.0	9.5	367d	N7	SU And	1.2°N	2.7°E
3	ST Cas	00h14.9m	+50°01′	9.0	10.5	Irr	N	VX And	5.6°N	0.5°W
4	AQ And	00h24.9m	+35°19′	6.9	8.2	332d	N	σ And	1.2°S	1.9°E
5	Z Psc	01h13.4m	+25°30′	7.0	7.9	144d	N0	ϕ Psc	1.2°N	0.6°E
6	R Scl	01h24.7m	−32°48′	6.1	8.8	363d	N3p	π Scl	0.2°S	3.2°W
7	Y Per	03h24.3m	+44°00′	8.1	10.9	252d	N	κ Per	0.7°S	3.3°E
8	ST Cam	04m46.0h	+68°05′	7.0	8.4	195d	N5	α Cam	1.8°N	0.3°W
9	TT Tau	04h48.4m	+28°27′	8.0	10 . .	166d	N3	ι Aur	4.6°S	1.2°W
10	R Lep	04h57.3m	−14°53′	5.9	11 . .	432d	N6e	μ Lep	1.4°N	3.2°W
11	W Ori	05h02.8m	+01°07′	6.5	10 . .	210d	N5	π^5Ori	1.2°S	2.8°E
12	TX Aur	05h05.7m	+38°56′	8.5	9.2	Irr	N3	η Aur	2.2°S	0.5°E
13	SY Eri	05h07.3m	−05°34′	9.0	10 . .	96d	N0	β Eri	0.4°S	0.5°E
14	UV Aur	05h18.5m	+32°28′	7.5	10.1	393d	Ne	β Tau	3.9°N	1.0°W
15	RT Ori	05h30.5m	+07°07′	8.0	8.9	320d	N3	γ Ori	0.8°N	2.0°E
16	U Cam	05h37.5m	+62°29′	7.7	9.5	412d	N5	β Cam	2.1°N	4.4°E
17	Y Tau	05h42.7m	+20°40′	7.1	9.5	241d	N2	ζ Tau	0.4°S	1.9°E
18	TU Gem	06h07.8m	+26°02′	7.5	8.4	230d	N3	1 Gem	2.8°N	1.5°E
19	KS Mon	06h17.3m	−05°16′	8.5	10.0	Irr	N	γ Mon	1.0°N	1.2°E
20	BL Ori	06h22.6′m	+14°45′	6.3	7.0	Irr	N3	ξ Ori	0.5°N	3.3°E
21	CR Gem	06h31.5m	+16°07′	8.5	9.5	Irr	N	γ Gem	0.3°S	0.8°W
22	VW Gem	06h38.9m	+31°30′	8.7	9.1	Irr	N	θ Gem	2.2°S	2.2°W
23	GY Mon	06h50.7m	−04°31′	7.7	8.9	Irr	N3	δ Mon	4.1°S	4.6°W
24	RV Mon	06h55.7m	+06°14′	7.0	8.9	132d	N	18 Mon	3.8°N	2.6°E
25	BG Mon	06h53.7m	+07°08′	9.2	10.4	30d	N	RV Mon	0.9°N	0.5°W
26	W CMa	07h05.7m	−11°51′	7.8	8 . .	Irr	N	θ CMa	0.1°N	3.4°E
27	RT Pup	08h03.6m	−38°38′	8.5	9.2	100d	N	ζ Pup	1.1°N	0.4°E
28	RU Pup	08h05.3m	−22°46′	8.9	11.1	425d	N	ϱ Pup	1.4°N	—
29	AC Pup	08h20.4m	−15°45′	8.9	10 . .	Irr	N	16 Pup	3.4°N	3.3°E
30	X Cnc	08h52.6m	+17°25′	6.2	7.5	170d	N3	δ Cnc	0.9°S	2.6°E
31	RT UMa	09h14.9m	+51°37	8.6	9.6	Irr	N	θ UMa	0.3°S	2.3°W
32	W Sex	09h48.4m	−01°48′	9.0	10 . .	40d	N	ι Hya	0.9°S	2.8°E
33	Y Hya	09h48.8m	−22°47′	6.9	9 . .	303d	N3	39 Hya	8.2°S	0.1°W
34	U Hya	10h35.1m	−13°07′	4.7	6.2	Irr	N2	υ Hya	3.5°N	2.8°E
35	U Ant	10h33.0m	−39°18′	5.7	6.8	170d	Nb	ι Ant	2.4°S	4.1°W
36	VY UMa	10h41.6m	+67°40′	6.0	6.6	Irr	N0	λ Dra	1.9°S	4.4°W
37	S Cen	12h21.9m	−49°09′	6.5	8 . .	65d	Np	γ Cen	0.5°S	2.7°W
38	SS Vir	12h22.7m	+01°03′	6.0	9.6	355d	Ne	η Vir	1.4°N	1.4°E
39	Y CVn	12h42.8m	+45°43′	5.0	6.4	158d	N3	α CVn	7.1°N	1.9°W
40	RY Dra	12h54.5m	+66°16′	6.0	8.2	170d	N4p	α Dra	1.6°N	6.9°W
41	SU Sco	16h37.4m	−32°17′	8.0	9.4	414d	N0	ε Sco	1.9°N	2.0°W
42	SZ Sgr	17h42.0m	−18°38′	9.0	10 . .	100d	N	ξ Ser	3.3°S	1.7°E
43	SX Sco	17h44.1m	−35°41′	8.5	9.5	Irr	N3	G Sco	1.4°N	0.5°W
44	V Oph	16h23.9m	−12°19′	7.3	11.5	298d	N3e	ζ Oph	1.8°S	2.6°W
45	SS Sgr	18h27.5m	−16°56′	9.0	10 . .	Irr	N	γ Sct	2.3°S	0.3°E
46	HK Lyr	18h41.1m	+36°54′	8.5	10.6	Irr	N	ζ Lyr	0.6°S	0.4°W
47	S Sct	18h47.6m	−07°58′	7.3	9 . .	148d	N3	β Sct	3.2°S	0.8°E
48	UV Aql	18h56.3m	+14°17′	8.6	9.6	340d	N	ζ Aql	0.5°N	1.6°W
49	V Aql	19h01.7m	−05°46′	6.6	8.1	350d	N6	λ Aql	0.8°S	0.5°W
50	V1942 Sgr	19h16.3m	−16°00′	6.7	7.1	Irr	N	ϱ Sgr	2.0°N	0.6°W
51	UX Dra	19h23.4m	+76°28′	6.2	7.0	170d	N0	τ Dra	3.2°N	0.4°E
52	AQ Sgr	19h31.4m	−16°29′	6.6	7.7	200d	N3	ϱ Sgr	1.5°N	3.0°E
53	TT Cyg	19h39.0m	+32°30′	7.8	9.1	118d	N3e	η Cyg	2.4°S	3.2°W
54	X Sge	20h02.9m	+20°30′	8.7	9.7	196d	N3	γ Sge	1.2°N	1.5°E
55	BF Sge	20h00.2m	+20°57′	8.5	10 . .	Irr	N3	X Sge	0.4°N	0.6°W
56	RS Cyg	20h11.6m	+38°35′	6.6	9.4	417d	Npe	γ Cyg	1.5°S	1.7°W
57	RY Cyg	20h08.5m	+35°48′	8.5	10 . .	Irr	N	RS Cyg	2.8°S	0.6°W
58	RT Cap	20h14.1m	−21°29′	6.5	8.1	395d	N3	π Cap	3.1°S	2.4°W
59	U Cyg	20h18.1m	+47°44′	6.7	11 . .	465d	Npe	32 Cyg	0.2°N	0.7°E
60	S Cep	21h35.9m	+78°24′	7.4	12.9	487d	N8e	γ Cep	1.0°N	6.1°W
61	V460 Cyg	21h39.9m	+35°17′	6.1	7.0	Irr	N1	υ Cyg	0.6°N	4.9°E
62	RV Cyg	21h41.2m	+37°47′	7.1	9.3	300d	N5	72 Cyg	0.5°S	1.7°E
63	RX Peg	21h54.1m	+22°37′	8.0	9.5	630d	N	ι Peg	2.5°S	2.4°W
64	19 Psc	23h43.8m	+03°13′	5.5	6.0	Irr	N0	λ Psc	1.7°N	1.1°E
65	WZ Cas	23h58.7m	+60°05′	7.4	10 . .	186d	Np	β Cas	1.2°N	1.0°W



Below left: *Lord Rosse's Crab Nebula drawing of 1844.*
Below: *Drawing of the Crab made in 1851.*
Below right: *Annotated drawing made in 1851.*
Below far right: *Photograph of the Crab Nebula by Preston Justis.*
Right: *Rosse's Crab Nebula drawing of 1855.*



The Visual Challenge of the Crab Nebula

by Alister Ling and Steve Lucas

At 2 a.m. local time on July 4, 1054 A.D., Chinese and Japanese court astronomers gazed up into a pristine, velvety black sky. They saw an object that at first mystified, then tantalized, and finally fascinated the world of astronomy. This object was the progenitor of the Crab Nebula in Taurus.

An astronomical treatise from the annals of the Sung dynasty compiled around 1345 A.D. contains the following references: "In the first year of the period *Chih-ho*, the fifth moon, the day of *Chi-ch'ou* [a guest star] appeared to the southeast of *T'ien-kuan* [Zeta Tauri]." The event was also recorded in an encyclopedia written about 1280 A.D.: "On the day *hsin-wei*, the first year of *Chia-wu's* reign, third month [April 17, 1056 A.D.], the Director of the Astronomical Bureau reported that the guest star that had appeared in the eastern heavens, had now become invisible."

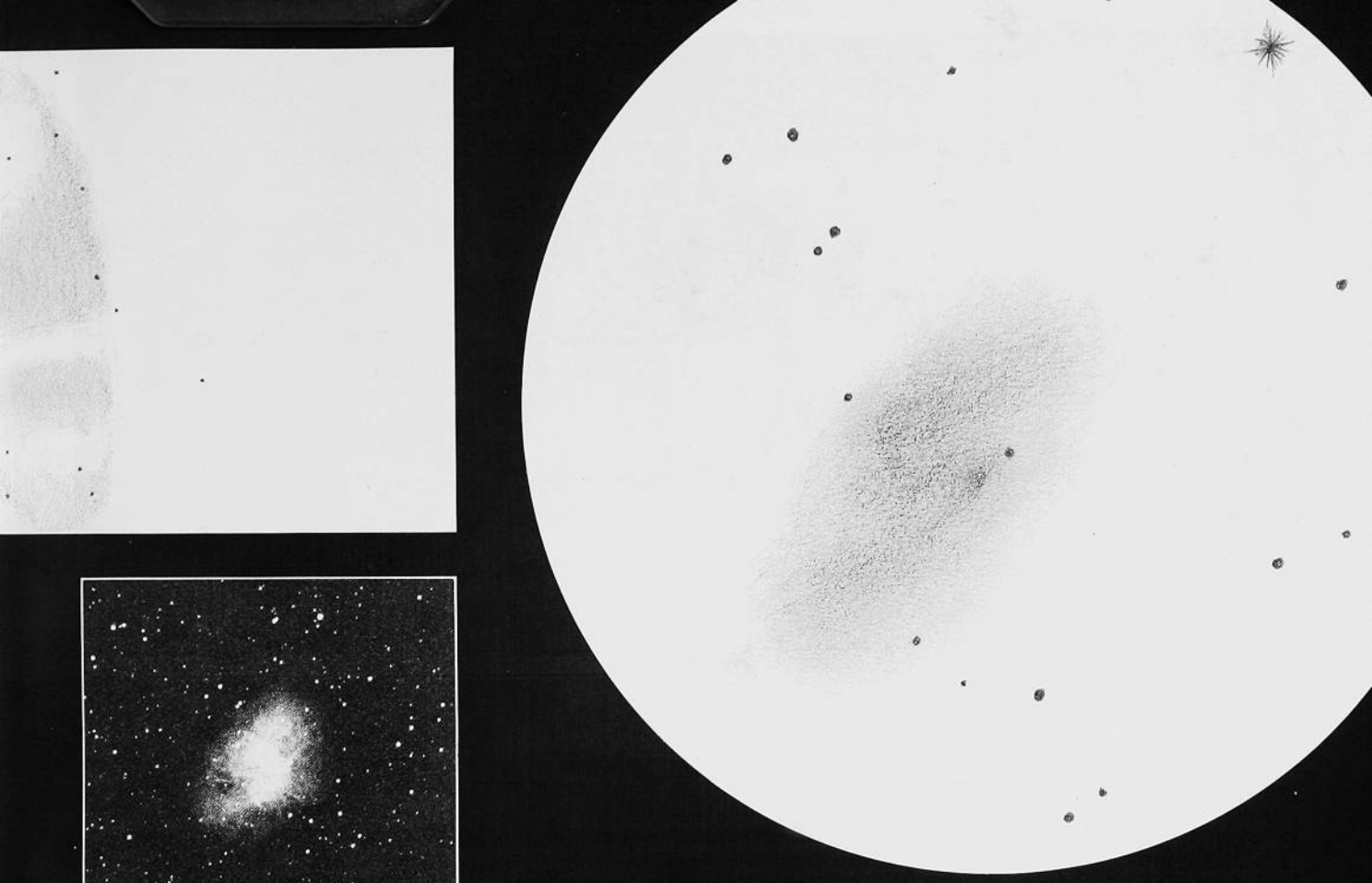
In North America Navajo Indians recorded the spectacular event with several pictograms showing a fiery diamond adorning a crescent Moon. Other areas, however, seemingly missed the event entirely: Europeans and observers in the Middle East left no records whatsoever of the Crab supernova. Could the Aristotelian logic then in vogue have dampened the tongues and pens of people who saw the event? We'll never know.

When he discovered the Crab Nebula in 1731, John Bevis had no idea the discovery he made involved such a sophisticated object. (Independently discovered by Charles Messier twenty-seven years later, the Crab became M1.) Powerful gravitational fields and strange quantum forces exist in the Crab. Electromagnetic effects on the interstellar medium display a unique light show. The Crab's relatively close distance of 2.0 kiloparsecs and high-velocity expansion rate (comparable to moving from New York to Cincinnati in a second) draw observers of all backgrounds and levels of experience to this marvelous object.

The first extensive observations of the Crab Nebula were made by Lord Rosse 150 years ago, yet they remain the most perceptive even today. Although Rosse was armed with 36-inch and 72-inch telescopes, you must remember that he did not have the benefit of enhanced silver coatings (only speculum!) or multicoated Naglers (Rosse often used single-lens eyepieces). Many of us own telescopes in the 16-inch to 24-inch range that can detect galaxies fainter than those discovered with Rosse's 72-inch scope, but can you ferret as much detail in the Crab Nebula?

Unlike today's amateurs, Lord Rosse and his assistants could not be influenced by photographs because none existed! Thus, we can view his drawings as unbiased, as real as the eye and the image-processing of the brain can produce, including our natural tendencies to define objects with lines, edges, and shapes. Over the years Lord Rosse has been unjustly maligned for his descriptions of spiral forms in ordinary galactic nebulae; however, in the vast majority of cases his keen eyesight picked up dark lanes that are easily verified on photographs. If you didn't know better, you could be easily convinced that the planetary nebula M76 is a barred spiral!

The most famous of Rosse's Crab Nebula drawings is the 1844 depiction showing numerous "hairy" appendages and a "resolved cluster" appearance.



The Crab Nebula sketched by Gregg D. Thompson with a 12.5-inch f/5 reflector at 330x. The seeing was subarcsecond and the sky very dark.

Rosse stated that "probably greater power would bring out other filaments, and it would then assume the ordinary form of a cluster. It is studded with stars, mixed however with a nebulosity probably consisting of stars too minute to be recognized." His experience in resolving reluctant globular clusters evidently had a profound effect on his thought processes. Indeed, Rosse's comments on the Dumbbell Nebula follow a similar trend: ". . .it is then seen to consist of innumerable stars, mixed with nebulosity; and when we turn our eye from the telescope to the Milky Way, the similarity is so striking that it is impossible not to feel a pretty strong conviction that the nebulosity in both proceeds from the same cause."

A few years later the Earl was not satisfied with the sketch and proceeded to make another. Before moving on to the next drawing, make a few comparisons with the photograph and imagine yourself at the eyepiece trying to squeeze out the most detail and in the process letting faint background stars contribute to the filamentary structure — he was on the right track.

The next three drawings were made between 1851 and 1855. Further observations were made until at least 1877. Here are Lord Rosse's comments, assisted by Mr. Stoney and Mr. Mitchell:

"1851, Nov. 24. Quite irregular along the edge; at α is a brighter portion of nebulosity with a dark space inside; another dark bay at β. Several stars throughout the nebula, which is quite patchy and very unlike h's figure [Sir John Herschel's drawing shows only a uniform oval]."

"1853, Dec. 28. Appeared very different from the drawing in the Phil. Trans. [1844]. α is a bright patch, apparently part of a longitudinal ray, β is a very dark bay, $\varkappa$ and λ slight dark streaks across the nebula, not seen very well. South of * γ an extraordinary beard projects from the general mass of the nebula."

"1854, Nov. 24. Can confirm preceding observations as to the existence of the second dark band λ, it is ill-defined and not so marked as $\varkappa$. The latter streak does not reach the whole way across to the triangular streak to the right of α."

"1855, Jan. 15. Drawing finished. The three faint stars north of the bay will be seen most distinctly when the bright main body has left the field. The part south of $\varkappa$ certainly resolvable."

"1877, Jan. 8. The so-called Crab Nebula. Compared two drawings by B. Stoney and Mitchell. The latter I think on the whole the best (Plate II); the north one of the two lanes in the north end not distinctly seen $\varkappa$. The large southern "bay" very conspicuous. The preceding appendage is best on Mr. Mitchell's drawing, query, does it end like a W? The north preceding end of the nebula is ragged. No trace of nebulous arms south as on the drawing from 1844."

If you take the time to compare the drawings with a recent photograph, we think you will agree they represent the Crab remarkably well. Under good conditions, large-scope owners should be able to duplicate these observations and perhaps even spot a few of the filaments because the filaments should appear as faint stars or streaks as they pop in and out of view while the seeing changes. Let *Deep Sky* know how you fare.

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Small Scope Showcase

Local Group Galaxies

by David H. Levy

Fall is a superb time to capitalize on the Andromeda Galaxy. Turn your telescope to M31, and be warned that this beautiful object is one of the sky's best galaxies. Even a small telescope in a suburban sky reveals the galaxy's oval shape. This mass of stars, gas, and dust produces a glow that travels to us over 2 million light-years of space.

When I started observing in 1962, M31 was not a galaxy but a nebula, as it had been for much of this century. Harlow Shapley, the director of Harvard Observatory and a man whose mind fashioned much of what we knew about cosmology before 1950, tried to change the traditional view that every nonstellar object in the sky is a nebula. His epochal book *Galaxies* suggested that a galaxy is fundamentally different from a nebula (Latin for cloud) and that these monstrous swarms of suns deserved to be called what they really were.

By the early 1960s much of the astronomical world, including our little observatory in Montreal, had accepted Shapley's ideas. At our meetings we were all sternly warned that anyone breathing the words "Andromeda Nebula" in lieu of "Andromeda Galaxy" would be fined twenty-five cents, the monies to go toward the group's educational program. As a *reductio ad absurdum*, some members felt like standing on chairs, repeating "Andromeda Nebula" over and over again, and then donating large amounts to what became a substantial education fund!

Actually, there are at least three M31s, one for your telescope, one for your binoculars, and one for your naked eye under a dark sky. Each view is so different that you'll feel that you're looking at a different object. When you look at it with your telescope, don't forget the neighbors, M32 and NGC 205. These satellite companions are anything but twins: M32 is bright and compact, while NGC 205 is larger and more diffuse. Because of evidence that Messier actually observed NGC 205, some amateur astronomers call this galaxy M110, although somehow I question the validity of adding to a man's list after he can no longer give permission.

M33 in nearby Triangulum was considered a difficult object when I first began observing. Even though it is one of the brightest spiral galaxies, its lumi-

Top: The faint, elliptical galaxies NGC 147 (left) and NGC 185 are satellites to M31 in Andromeda. Photo by Martin C. Germano with an 8-inch f/5 Newtonian, 103a-F film, and a 30-minute exposure.

Above: M31 is the brightest spiral galaxy in the sky, visible as a diffuse glow to the naked eye. Photo by Bill Harris with an 8-inch f/4 Wright-Newtonian, hypered Tech Pan film, and a 60-minute exposure.

Above right: M33, the Pinwheel Galaxy in Triangulum, is a borderline naked-eye object. Photo by Tom Eby with an 8-inch SCT at f/5.6, hypered Tech Pan film, and a 51-minute exposure.

nosity is spread out over a large area of sky, enough to cover a good portion of the field of a small telescope. Twenty-five years ago a 6-inch f/8 refractor was the standard telescope, and its narrow field and a Kellner eyepiece were barely enough to show M33 at all. The telescopes were good quality instruments, but M33's light is spread out over such a large area that its surface brightness is not much greater than that of the surrounding sky background. An object like this has "low surface brightness" — which means it plays hard to get at any price or aperture. Today's typically faster and larger telescopes aren't optically any better, but their focal ratios and sizes make objects like M33 a bit easier to spot against a dark background.

A much smaller galaxy than M31, M33 presents itself almost face-on, while we see M31 as a highly inclined disk. M33 also displays many bright, starlike spots, known as H II regions consisting of ionized hydrogen. Also, there are many foreground stars, actually in our own Galaxy, that you may think are part of M33. Some of these objects have even been falsely reported as supernovae, so don't be fooled!

These galaxies are members of our own family of galaxies, called the Local Group. Nearby in Cassiopeia are two other members: NGC 147 and NGC 185. These are dwarf ellipticals that have such low surface brightness they are barely visible. I find they look like faint comets through a 16-inch reflector. Our local group has other such members, two of which are in Leo. Known as Leo I and Leo II, these objects have such low surface brightnesses that they are impossible to see without a near-perfect sky and a large telescope.

Closer to home, fall offers the Double Cluster in Perseus, one of the prettiest things in our Galaxy. Known as NGC 869 and NGC 884, these adjacent open clusters are particularly delightful through 6- or 8-inch short focal length telescopes. The Double Cluster is clearly visible without a telescope and even from a suburban sky it is an easy binocular object.

How clear is a clear sky? The transparency of a dark sky varies widely from place to place, depending on factors like pollution, humidity, and dust. Here are some typical limiting naked-eye magnitudes at sites I have tried. The weather each time was completely cloudless with no Moon:

7.2 South rim of Grand Canyon, Kitt Peak, Texas Star Party
6.5 My backyard
4.5 My former home, in Montreal
3.5 Our little observatory in Montreal
1.0 A street in Las Vegas (could see Vega and Altair but not Deneb)

Because Northern Hemisphere weather is usually at its best in the fall, we can count on several good nights with cool temperatures under which we can enjoy the sky. Obviously your deep-sky observing will be more successful at the Texas Star Party than on the Las Vegas strip, but even under a moderately good sky you should let the sky conditions dictate what objects you want to observe. The night sky is a busy place even when the Moon is Full. Because a Moon will wash out most deep-sky objects, except for globular and open star clusters, this is the time to study Mars, which is presenting itself in one of its best apparitions this century. There are also double stars that need separating and variables that need estimating. Take advantage of clear nights and enjoy the sky.

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Double Stars

Circulaire d'Information

by Brian Skiff

The physical study of double stars is undergoing a renaissance thanks to improved technology and a renewed interest in low-mass companions to stars similar to the Sun. The new technology is speckle interferometry to make potential measurements of extremely close pairs, which enables orbits to be calculated for these pairs with a precision unheard of heretofore. The interest in discovering and studying the least massive stars and even planetary-massed objects around nearby stars has led to a great increase in photometry of double stars, particularly in the infrared, where the purported companions shine brightest (if at all).

Even with this observing boom, traditional double star astronomy continues, albeit at a fairly low level: only a handful of observers work in this field. Orbits continue to be derived, new pairs discovered, and new micrometric measurements accumulated. The most rapid means of communication among professional double star observers is provided by the *Circulaires d'Information*, sponsored by Commission 26 of the International Astronomical Union. The *Circulaires* are currently produced by well-known double star observer Paul Couteau from the Nice Observatory near the Mediterranean coast of France.

A typical issue from about a year ago is reproduced here. Printed on two sides of a single sheet of paper, the *Circulaire* contains a list of new orbital elements for ten double stars and announcements for fourteen newly discovered pairs. The first page gives orbital elements in condensed form. Included are the ADS numbers (if any) and discoverer names for the stars concerned as well as IDS designations, which are in the form of coordinates for equinox 1900. Among the elements themselves are P, the period, and T, the date of periastron passage, i.e., the date when the companion is closest to the primary star. Note that this is not the date when the two stars appear closest from Earth, but when they are closest to each other in space.

Under the dates 1988.0/1989.0 are brief ephemerides for the pairs. As you can see, nearly all are extremely close: several have current separations less than one tenth of an arcsecond. These very close pairs have the shortest periods, and hence their orbits can be derived after only a few years observation. The pairs commonly viewed by amateurs have periods measured in centuries and so do not provide much fodder for the orbit-grinding mill. Even after 150 years of double star observation (since the early measures of Struve about 1830), the pairs have moved only a little, and their current orbital elements are quite likely to be in error. The elements listed here for pairs with periods longer than about three hundred years should be regarded as preliminary.

Of the reasonably wide pairs, ADS 4562 in Orion should be recognizable in a sharp 8-inch telescope in good seeing; a 12-inch will be required for true resolution. Its components are roughly equal at about magnitude 8.5. For Southern Hemisphere observers, See 318, located in Scorpius, should be observable in a 6- to 8-inch. At the bottom of the list, ADS 15270 — better known as Mu (μ) Cygni, is a good target for a small instrument. Can someone split it with a 2.4-incher? All three of these pairs are located in *SkyCat2*, where equinox 2000 positions and other information can be found.

The second sheet lists some new objects found by Couteau with the 50cm refractor at Nice and George Popovic with a 65cm instrument in Yugoslavia. None of the Couteau pairs is an easy target, because they are both very close and relatively faint. My experience suggests that an excellent 12-inch or 16-inch will be necessary to glimpse most of these. The table lists positions for both 1900 and 2000 (end figures only), and some of the stars are bright enough to be plotted on *Uranometria* or *Atlas Borealis*.

Most professional double star observers argue that the discovery of new pairs is a totally unnecessary pursuit. They feel that plenty of doubles are already known that desperately need further observations, and one should be using precious good-seeing telescope time to keep up with them rather than discovering more objects that will be neglected. But then, as Paul Simon sang, "everybody got the runs for glory. . ."

Nevertheless, it is fun to view pairs that have been seen for the first time only a few months before. To that end, I have made a short list of reasonably accessible pairs bright enough (with a notable exception) to have been in the *SkyCat2* list. They were all discovered after 1975, the closing date for the *SkyCat2* source catalogue. I have tried to view some of these but haven't had the opportunity to check them all. I'd be pleased to hear from anyone who spots them.

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UNION ASTRONOMIQUE INTERNATIONALE — Octobre 1987
COMMISSION DES ETOILES DOUBLES

Circulaire d'Information N° 103

ORBITES NOUVELLES

ADS / IDS	Nom	P / n	T / a	e / i	Ω / ω	1988,0 / 1989,0		Auteur / dern. obs.
4562	0Σ 124	140	1912,0	0,56	120°5	299°7	0"46	Baize
05533N1248		2°5714	0"30	80°.	350°.	299,8	0,46	1983,97
4866	A 668	106,38	1984,20	0,70	20,0	255,0	0,074	Baize
06107S0900		3,3841	0,185	29,5	161,5	266,8	0,082	1985,85
8831 Aa	φ 297	61,47	1969,88	0,64	162,5	325,7	0,23	Baize
13090S2345		5,8565	0,165	37,5	2,3	327,5	0,24	1984,38
-	φ 350	8,989	1981,933	0,65	177,5	37,6	0,088	Baize
13124S0009		40,049	0,086	58,9	39,8	59,4	0,060	1985,48
-	See 318	224,19	1878,14	0,61	47,7	356,2	0,76	Erceg-Olevic
16594S3829		1,6058	0,675	52,2	117,1	356,8	0,77	1979,19
-	I 600	600,0	1955,0	0,36	120,5	153,7	0,28	Erceg-Olevic
17225S6022		0,5829	0,494	131,5	287,5	152,6	0,28	1979,21
-	φ 381	8,320	1980,276	0,287	153,2	164,8	0,069	Baize
17496N1108		43,2692	0,091	144,0	32,1	94,0	0,057	1985,52
-	McAl 56	4,123	1984,484	0,27	71,0	178,8	0,063	Baize
19295N5824		87,3151	0,136	120,1	343,4	47,4	0,091	1985,49
-	δ Sgt	9,681	1979,862	0,36	149,5	8,5	0,042	Baize
19429N1817		37,1862	0,0494	147,6	235,2	319,6	0,034	1985,48
15270	Σ 2822	713,19	1960,28	0,628	111,2++	299,8	2,03	Docobo-Costa
21397N2817		0,50477	5,021	76,8	148,0	300,4	2,02	1987,65

++ Equinoxe 2000

Discover the Autumn Variables

by David H. Levy

With summer doldrums gone, autumn is the time to tell your friends and fellow astronomy club members about the beauty of variable stars. The cold of winter with its endless slide shows of M42 has not yet begun, so get out and get into variables!

I don't know of many people who are indifferent about variable stars. Many observers just don't like them; somehow these people think that a star parading about on a stage, displaying changing brightness for all to see, is boring. Others have seen the changing light and love to observe variable stars. It has always been my purpose in this column both to try to convince the first group that variables are a worthwhile pursuit and to share my feeling about variables with the already converted.

In autumn we can observe Algol in all its glory — dropping and then rising a full magnitude in plain view of anyone on the planet who cares to look — and use it as a motivation to start observing other variables.

Let's look at a collection of some of the less well known variables that are up (or down) in the fall sky. Many of these are Mira types: they follow roughly the behavior of their prototype, Mira, which involves a fall and rise of several magnitudes over a period of months. Most Miras should be estimated every two weeks or so.

Capricornus, the sea-goat, is a little known constellation that is busy with variables, one of which is 201121 **RT Capricorni,** a Mira-type star that has a range from 8.0 to 11.0 and a period of 393 days from one maximum to the next.

Delphinus, high overhead these evenings, has two interesting Mira-type variables, 201008 **R Delphini,** with a range from 8.3 to 13.3 and a period of 285 days, and 203816 **S Delphini,** with a range from 8.8 to 12.0 and a period of 277 days. 204017 **U Delphini** is a bright variable of a different type: it's irregular with a visual range of approximately 7 to 8.

Pegasus and Andromeda have a fine selection of variables. Here is a sampling:

230110 **R Pegasi.** With a range of six-and-a-half magnitudes (7.8 to 13.2) and a period of over a year (378 days), R Pegasi is an autumn variable easy to find. It forms an isosceles triangle with 55 Pegasi and 58 Pegasi, two stars of about 5th magnitude. 231508 S Pegasi is also a Mira star; it ranges from 8.0 to 13.0 in a period of 319 days.

220412 **T Pegasi** is a Mira star that varies by five-and-a-half magnitudes, from 8.9 to 14.3, and is located over 2.5° north and less than half a degree east of Epsilon Pegasi. Its period is just slightly over a year at 375 days.

020448 **RV Andromedae.** This semiregular variable ranges from 9.0 to 11.5 and has a period of 172 days. The lack of bright stars nearby make this star a bit difficult to find. Semiregular means the star seems to have a period and range of variation that is well established, but either or both are uncertain from cycle to cycle. Semiregulars are typically more luminous than Miras. RV Andromedae has a special meaning to me because the first night I observed it a sudden gust of wind grabbed the chart and sent me running around a campground in an ultimately unsuccessful effort to save it. Anything for a variable star observation!

233335 **ST Andromedae.** This Mira star varies from 8.2 to 11.8 in a period of 334 days. Like many variables in the sparsely populated constellation of Andromeda, this one may be hard to find. Try moving south 2.5° and then east by half a degree. Estimate this one twice a month.

001828 **SW Andromedae.** Harvard University has a huge collection of photographic patrol plates that contain a record of the sky for more than a century. Taken routinely each clear night, plates covering almost the entire sky visible from Harvard contain information on every variable star brighter than about 12th magnitude.

During her monumental study of the Harvard photographic plate collection Annie Jump Cannon discovered SW Andromedae, an unusually long eclipsing binary with a period of 37 days. Its one-magnitude drops, from 9.3 to 10.3, are followed by fairly flat periods around minimum that last about four hours and are followed by faster rises to maximum. The period is lengthening by about fifteen minutes every ten years.

Now let's move north into Lacerta, Cepheus, and Cassiopeia.

225248 **EW Lacertae.** We include this unique star for interest's sake. Because its variations are about a third of a magnitude, one would normally not observe it visually. Though it typically varies in 0.7 days, according to the *General Catalogue of Variable Stars,* not all the minima actually took place in 1951, and the following year the period changed. EW Lacertae is surrounded by a shell of materials, and it may also have a large and variable "star spot" that may be partly responsible for these strange cycles of variation.

213678 **S Cephei.** A north circumpolar star observable the year round from most Northern Hemisphere sites! This fortunate fact of position enables you to watch this star complete cycle after cycle without any breaks. It varies by six magnitudes, from 7.1 to 13.2 and back, in a period of 485 days. Because its period is longer than that typical for Miras, estimate once every two or three weeks.

005381 **U Cephei.** An eclipsing star with a difference, U Cephei is undergoing a change of period, possibly because of an exchange of gas from one star to the other. This star drops more than two full magnitudes — from 6.7 to 9 — in slightly less than 2.5 days. The period is increasing gradually by a very slight amount, but on rare occasions it can change more suddenly.

235350 **R Cassiopeiae.** A bright maximum of 7.0 makes this an easy variable to observe if it is bright. Minimum at 12.6 offers a different picture, for the star is in a richly star-studded part of the sky. You may confuse a faint R Cassiopeiae with other stars in the field, particularly a magnitude 11.4 star very close by. Its period of 431 days is slow, so an estimate once every two weeks should be sufficient, except around maximum or minimum when you should estimate every few days. Both the maxima and the minima change considerably.

230759 **V Cassiopeiae.** Our last star this column, which lies halfway between the bright stars Beta Cassiopeiae and Zeta Cephei, is a Mira star called V Cas. Its closeness to 1 and 2 Cassiopeiae further eases the finding process. The star varies between 7.9 and 12.2 in 228 days. V Cassiopeiae was discovered as variable by Thomas Anderson of Scotland in 1893 with a 2.5-inch refractor. While discoveries with instruments this size are rare, they are not impossible.

Enjoy observing variable stars this autumn. From the slow, predictable churnings of stars V Cassiopeiae and T Pegasi to the imperceptible changes in EW Lacertae, they're waiting for you.

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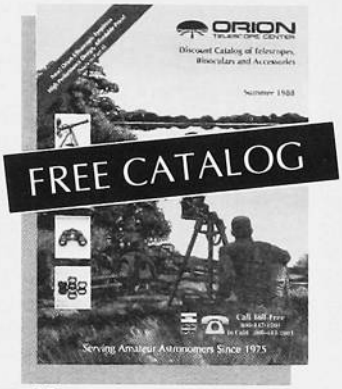

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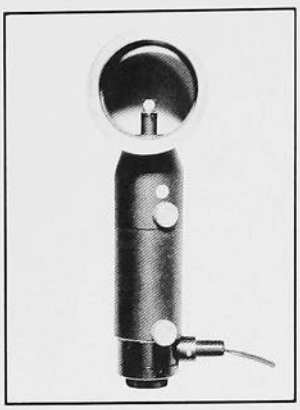

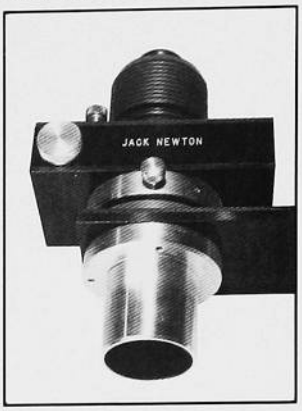

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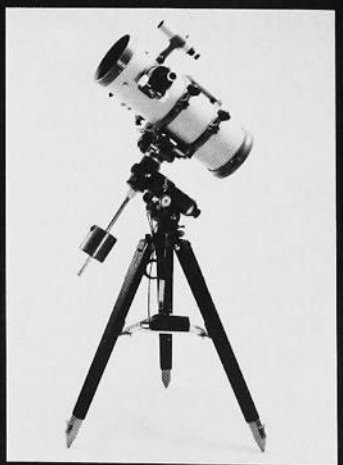

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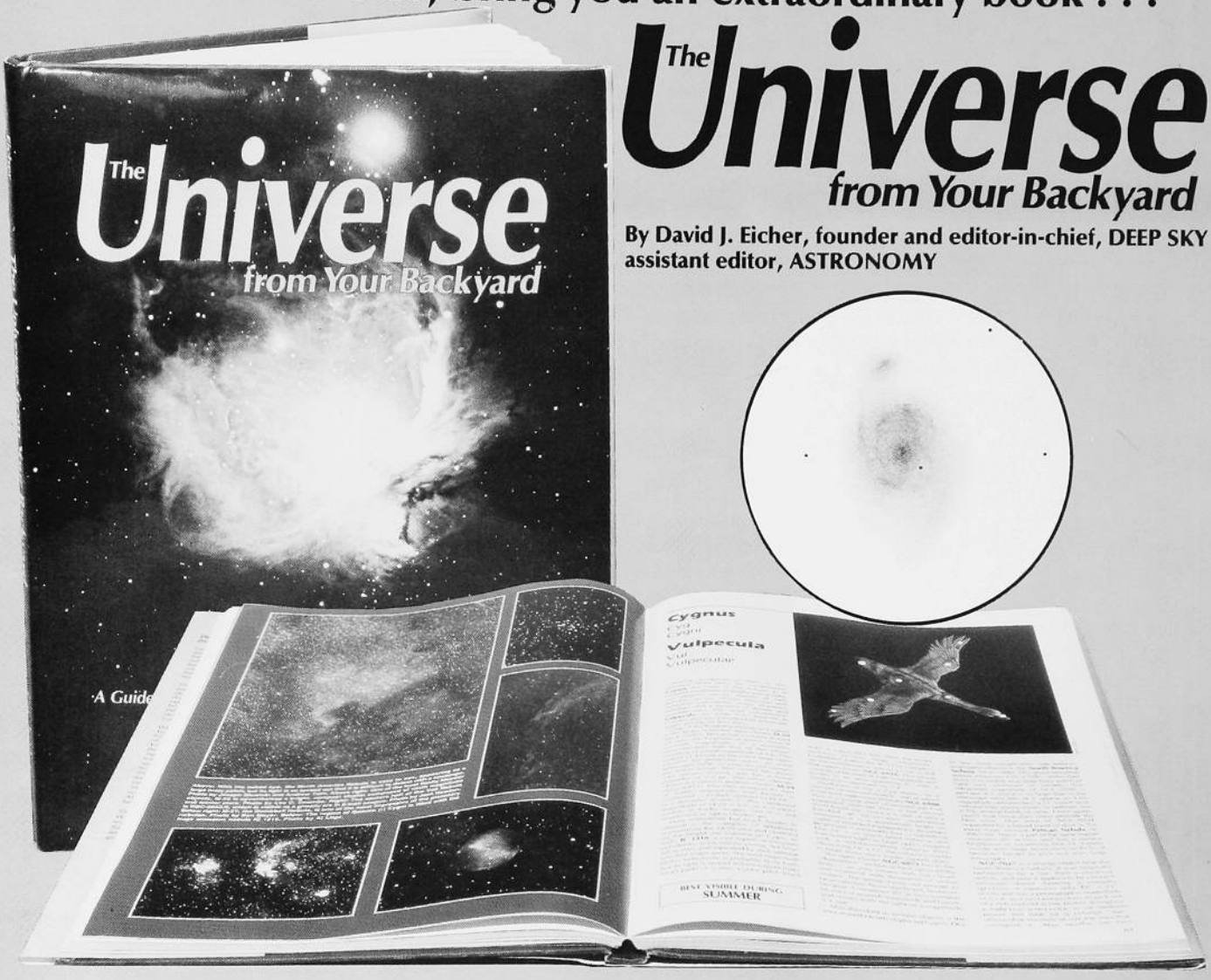

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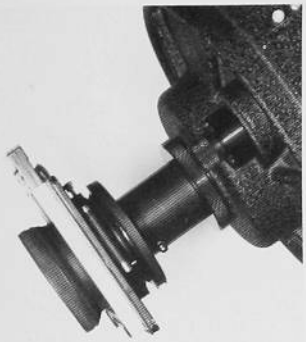

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MINOR AXIS	COATING #1	COATING #2	COATING #3
2.1"	$ 75	$100	$115
2.6"	75	100	115
3.1"	95	120	150
3.5"	265	300	330
4.0"	285	325	360
5.0"	425	475	500

All mirrors are available in many popular focal ratios. Full thickness (1:6) and ultra-lightweight Zerodur® Optics available. Mirror refiguring services, write for quotation. For a complete product catalog mail $1.00 to:

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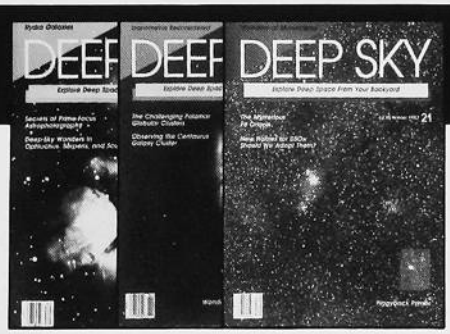

DEEP SKY BACK ISSUES

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Here's your chance to complete your collection of DEEP SKY! Limited quantities of DEEP SKY back issues are available, each one featuring 40 pages of information and beautiful deep-sky photos. In DEEP SKY, you'll discover articles on equipment, observing, and astrophotography techniques plus handy maps, observing aids, and sketches.

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All About M31, the Andromeda Galaxy, Choosing a Film for Astrophotography, Cassiopeia's Bright Open Clusters

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Observing Exotic Objects – Quasars, Interacting Galaxies, and Black Hole Sites, Galaxies in Eridanus the River

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LUMICON

HIGH PERFORMANCE TELESCOPE PARTS

LUMICON® SKY VECTOR™- *NEW!*

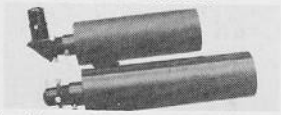
Computer-Controlled Digital Setting Circles, from $498

Incredibly Smart! thus Incredibly Easy!

- Digital right ascension readout to 1 minute of R.A.
- Digital decl. readout to 10 arc-min
- Digital altitude readout to 1°
- Polar alignment **not required!**
- Just sight two stars!
- Works for alt-azimuth **and** equatorial mounts

LUMICON Sky Vector™ (state scope) **$498**
Sky Vector™ Kit (you supply hardware) **$469**
Pair digital shaft encoders (for 2nd scope) **$135**

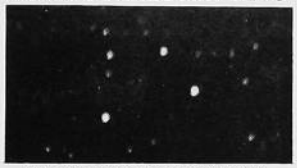
LUMICON 50mm, 80mm SUPER-FINDER™



Visual Astronomers perfer the LUMICON 80mm SUPER-FINDER™, since hundreds of deep-sky objects, including most Messier objects, are visible directly. SUPER-FINDERS also make nice small portable telescopes. 80mm aperture, F = 300mm coated achromat. The deluxe SUPER-FINDER uses an 80mm, F = 500mm air spaced achromat.

1¼" 50mm Finderscope **$59.50**, right-angle **$89.50**
1¼" straight-thru 80mm SUPER-FINDER **$169**
1¼" right-angle version, w/star diagonal **$195**
2" right-angle version, non-rotating focuser **$199**
1¼" Deluxe right-angle Super-Finder **$279**
2" Deluxe right-angle Super-Finder **$309**
25mm Cross-hair 1¼" eyepiece (12X) **$29**
1¼" Star Diag. . . **$32**, 2" Star Diag., silver, . . **$145**
1¼" Amici Prism diag. for correct left-right views **$59.50**

COMA CORRECTOR LENS



Coma 1 inch off-axis (17½" f/4.5)

Same Field with LUMICON coma corrector lens; note smaller, more numerous stars.

This computer-designed LUMICON 2" lens reduces coma and flattens the field for both viewing and photography. It threads into LUMICON 2" EASY-GUIDERS for effortless installation. This lens is optimized for f/4.5 and reduces aberrations for f/3.5 to f/5 Newtonians. Off-axis images are much smaller, making off-axis guiding far easier and yielding round pinpoint star images in photos. Since star images are sharp over a full 2¼" circle, you can use medium format cameras in addition to 35mm cameras. This zero power lens does not change image scale nor shift focus, and all lens surfaces are multi-coated for highest efficiency. Although designed for photography you may also use this lens to improve image quality in wide-field viewing with low power eyepieces.

LUMICON Coma Corrector/Field Flattener
2" lens **$285.00**
Extension tube for viewing **$26**
2" Easy-Guider™ (state camera) . . **$169.50**

LUMICON®
2111 Research Drive #5T Livermore CA 94550
For phone orders please call (415) 447-9570
LUMICON Products catalogue $2.
Foreign orders add $8 ($20 for HYPER-KITS)
California Residents add 6% tax.
Prices subject to change w/o notice.

NEW! ENCHANCED SILVER DIAGONAL MIRRORS BOOST TELESCOPE PERFORMANCE

LUMICON 1.3" & 3.1" enhanced silver diagonal mirrors & 2" star diagonal.
The new LUMICON diagonal mirrors have a special enhanced silver coating with a protective overcoating for long life. Visible reflectivity is 98-99% compared to 86-89% for standard aluminum coated mirrors. The extra 10-12% transmission is like adding an inch of aperture! The substrate is fine annealed Pyrex flat to 1/8 wave.

1.32" **$29.95** 1.52" **$34.50** 1.83" **$39.50**
2.14" **$49.50** 2.60" **$65.00** 3.10" **$89.50**
4.25" **$149.50**

ENHANCED SILVER STAR DIAGONAL

90° star diagonals with above enhanced silver mirrors in a CNC machined black anodized aluminum body. Performance far exceeds prism diagonals.
1¼" (1.32" mirror) **$89.50**
2" (1.83" mirror)(see photo above) . . **$145.00**

OXYGEN-III FILTER

Helix Nebula, NGC 7293 in Aquarius. Bright and easy with Lumicon Oxygen-III Filter.

The ultimate in filter performance! The Lumicon Oxygen-III Filter has a contrast twice as high as the high performance Lumicon UHC Filter™. Use the Oxygen-III Filter for observing the very faintest planetary and diffuse emission nebulae. Also gives incredible views of bright nebulae (like M-27, M-17, etc.) from urban locations. Bandpass is 11nm, transmission is 90% for both O-III lines at 496nm and 501nm.

Filter Type	1¼"	48mm
Lumicon Oxygen-III	**$99.50**	**$199.50**
Lumicon UHC	**$99.50**	**$199.50**
Lumicon Deep-Sky	**$79.50**	**$119.50**
Set UHC and Oxygen-III .	**$190.00**	**$380.00**

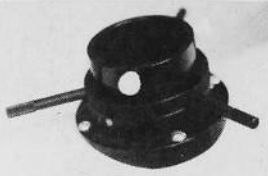
NOTE: The Oxygen-III Filter is not a substitute, but a compliment to the UHC Filter. **1 year guarantee:** You must see nebulae with the O-III filter that are **invisible** without a filter.

NEW ADJUSTABLE PIGGYBACK MOUNT

LUMICON has just designed a new adjustable piggyback mount ideal for all telescopes of 8-14" aperture. It has **both** vertical and sideways adjustment to allow optical alignment. It was designed to allow mounting of the LUMICON SUPER-FINDER on C-8, C-14, etc., but is ideal for any telephoto lenses or small telescopes.

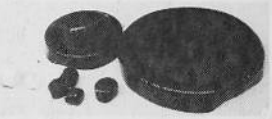
Deluxe Piggyback Mount **$45.00**
(State Telescope Type)
LUMICON 12x80mm SUPER-FINDER . $170

NEW! LOW PROFILE HELICAL FOCUSERS



LUMICON® DELUXE NON-ROTATING HELICAL FOCUSER on a 6" telescope.
LUMICON now offers 3 different low-profile helical focusers. They stand only 1¼-1½" above the telescope tube. Use the 1¼" or 2" versions for viewing. Use the 2" non-rotating focuser for convenient photography with the LUMICON 2" EASY-GUIDER™.
Select your desired base-plate shape!
Flat, 7" OD, 9½" OD, 12½" OD, 16" OD, 21" OD, SUPER-FINDER base plate.
LUMICON 1¼" Helical Focuser **$49.50**
LUMICON 2" Helical Focuser **$59.50**
LUMICON Non-rotating Helical Focuser $79.50
3 handles (see photo) for non-rotat. focuser **$12.95**
2"/1¼" adapter w/48mm filter threads . . **$20.00**
2" LUMICON EASY-GUIDER **$169.50**

PROTECTIVE DUST COVERS



Protective plugs (left), vinyl dust covers.
Protect your valuable telescope optics, eyepieces and accessories with these black vinyl covers. Add $1 shipping. Deduct 10%, 2 or more sets.

1¼" O.D. plug, seals focuser	**4/$2**		
2" O.D. plug .	**2/$2**	3½" O.D. plug	**$1.50**
1¼", 1⅜"	**3/$2**	7½"	**$8**
1½"	**2/$2**	9½", 10.4"* . . .	**$12**
2"	**2/$2**	12½", 12⅞"* . .	**$15**
3½", 4½"	**$5**	16"*	**$20**
5½"	**$6**	19" (DS-16) . . .	**$27**

*Fits Odyssey

MAKE YOUR OWN ASTROGRAPH

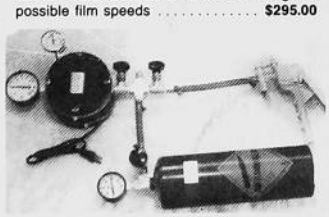
FILM HYPERSENSITIZATION KITS†

LUMICON HYPER-KITS™ yield 3-15X film speed gain in long exposures. They are safe & simple to use. Easy HYPER-KIT includes a chamber with all controls and fittings, thermometer, a refillable cylinder of non-flammable forming gas & hand-operated vacuum pump.

†U.S. Patent 4,473,636

MAKE YOUR OWN HYPERED FILM

MODEL 300 HYPER-KIT sensitizes any 35mm film in hours. Best for 2415. Achieves highest possible film speeds **$295.00**



MODEL 600 HYPER-KIT (See Photo) Like the Model 300, but also sensitizes 120/220 larger format film and small glass plates **$350.00**

MODEL 1200 HYPER-KIT is for 4X5" plates and film up to 5X7". Has 2 gas cylinders and includes temperature controller **$595.00**

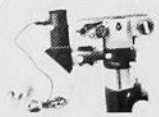
Temperature controller for any HYPER-KIT **$59.50**

Electric Vacuum Pump **$280.00**

GUIDE OFF-AXIS FOR LOVELY ASTROPHOTOS

All **LUMICON EASY-GUIDER™** off-axis guiders† have both radial and 360° rotational adjustments for 5X easier guide-star selection, use 48mm filters, 360° camera rotation, large prisms of bright guide-starts. *Specify Camera and Telescope type.*
U.S. Patent #4,448,500

NEWTONIAN EASY-GUIDER™



Full aperture. Installs in secs. Specify 2" or 1¼".
NEWTONIAN EASY-GUIDER **$169.50**
3X Relay Diagonal (see photo) **$79.50**
Illuminated reticle eyepiece system . . **$79.50**
Guider for Hasselblad **$350,** Mamiya 645 **$159**

CASSEGRAIN EASY-GUIDER™

For C-8, Meade 2080, Dynamax-8. Includes 50mm achromatic lens for f/5.8 operation —3X shorter 6x-posures! **Superb rich field viewing, too!**
CASSEGRAIN EASY-GUIDER **$225.00**
Adapter for Hasselblad $185, Mamiya 645 **$159**

GIANT EASY-GUIDER™

For Celestron-11, C-14, and the 10" Meade 2120. Includes 80mm clear aperture achromatic lens for edge-to-edge illumination & pin-point star images. F-ratio adjustable f/4-f/11. **Also yields unmatched Rich-Field viewing.**
GIANT EASY-GUIDER **$395.00**
48mm DEEP-SKY Filter ordered with any EASY-GUIDER (SAVE $20) . . . . . **add $99.95**
Adapter for Hasselblad adapter **$195,** Mamiya 645, **$96**

WHAT DO YOU NEED?

1. Illuminated reticle eyepiece **$79.50**
Lumicon 12mm eyepiece system has adjustable L.E.D. illumination, dual crosslines, battery pack.
2. Cable release for long exposures . . **$9.95**

3. **LUMICON Quartz Drive Corrector . $219**
Dual-axis drive corrector is essential for astrophotography and/or field use of your telescope. 40Hz/80Hz variable output controls telescope drive. 60Hz Quartz reference ±12VDC Declination control output. Both 110VAC and 12VDC input for home or field use. Declination reverse switch for Newtonians.
Declination motor (state telescope) . . $70
NEW Deluxe Digital Qtz. Drive Correc. **$298**

HYPERSENSITIZED FILM
LUMICON Hypersensitized film is essential for good deep-sky astrophotography. Deduct 10% for 3 or more rolls (mixed o.k.).

Film Type, 35mm	Exposures	Price
2415, Ultra-fine B&W, red sens.	36	**$10.95**
SR3200, fastest of all, color neg	24	**$13.95**
Konica SR400, fine gr. color neg	12	**$10.95**
3M 1000, fastest slide film	20	**$12.95**
Fujichrome RD100, fine gr. slide	24	**$12.95**
5072, color slides from negs	36	**$6.95**
D-19 B&W Developer	1 gal.	**$6.95**